

# SCIENCE

18 October 1957

Volume 126, Number 3277

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# *The Collected Papers of* **PAUL EHRLICH**

*Compiled and edited by Dr. F. HIMMELWEIT, Director of the Department of Virus Research, The Wright-Fleming Institute, St. Mary's Hospital Medical School; with the assistance of the Late MISS MARTHA MARQUARDT, and under the editorial direction of SIR HENRY DALE.*

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10638 South Wilton Place, Los Angeles 47, California 24 Rue des Ecoles, Paris Ve.

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SCIENCE, founded in 1880, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879.

SCIENCE is indexed in the *Reader's Guide to Periodical Literature* and in the *Industrial Arts Index*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: \$7.50; foreign postage, \$1; Canadian postage, 50¢. Single copies, 25¢. Special rates to members of the AAAS. Cable address: Advancesci, Washington.

Rates effective 1 January 1958: \$8.50; foreign postage, \$1.50; Canadian postage, 75¢. Single copies, 25¢.



## Ups and Downs in Research Support

The United States debt is approaching its statutory limit. This fact is the primary justification for the recent order to the Department of Defense and other Federal agencies to reduce expenses. In the application of this general order to specific budgets, one of the most drastic of the cuts reduced the funds of the Office of Scientific Research—the Air Force office with responsibility for supporting basic research—to half of its appropriated \$16 million. Since \$8 million was barely sufficient to meet obligations already incurred, new contracts could not be written and most expiring contracts could not be renewed.

Repercussions were immediate, and went far beyond the enforced alteration of personal and research plans of a number of scientists. According to *Aviation Week*, one university announced that it would accept no more Air Force contracts for basic research because of the difficulty of working under such financial uncertainty. Scientific advisors to the Government and directors of military research programs protested that such sudden changes caused irreparable harm to the military research program, that the sudden termination of a contract not only produces immediate disruption but also deprives everyone concerned of much of the potential benefit of the money invested during previous years, and that the military services were weakening their ties with civilian science.

These arguments have led to a partial restoration of the cuts. The Office of Scientific Research has had its budget restored to the \$16 million level. But not all military research and development agencies will be so fortunate, and, indeed, the restoration of this one fund is likely to be at the expense of other research budgets.

Restoration of the Office of Scientific Research funds will be of immediate satisfaction to the office and its contractors, but the basic problem remains untouched, and is in fact well illustrated by the rapidity of the recent reduction and restoration. The officers responsible for research planning and administration understand clearly that basic research is an investment, that one cannot walk into a research laboratory and buy a bit of research off the shelf. They know that time is required to organize an effective research staff and program, and that the return on money invested in basic research is normally a cumulative one spread over a number of years. These points are widely understood, but not widely enough, so it is encouraging to note the understanding of the nature of basic research expressed by the new Secretary of Defense in his first press conference.

The fundamental problem involved cannot be solved until the importance of continuity is generally recognized. Permanence of support of a particular contract is not necessary and neither is a steadily rising budget, but continuity and advance planning are. A moderately steady amount, at any level, will bring a better research return than will widely fluctuating amounts that average at the same level. The current difficulties provide an object lesson on the importance of damping out big swings in basic research expenditures, just as the current pressure to catch up on the earth satellite program points up the error of the erratic earlier support of rocket research.

This is one aspect of a more general issue. The military services have decided that they should contribute to the support of basic research. Although this decision has executive and legislative endorsement, it does not yet have unanimous support throughout the Department of Defense. Nevertheless, the decision will probably prevail, and the services will continue to support basic research. That being the case, it appears to be an obligation of the officers and civilians responsible for over-all administration to consult with their own research administrators and to learn how to make the military support as effective as possible.—D.W.



Shown at Bell Laboratories, Murray Hill, N. J., are, left to right, F. J. Herr, S. T. Brewer, L. R. Snoke, E. E. Zajac and F. W. Kinsman.

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**E. E. Zajac, Ph.D. in Engineering Mechanics**, Stanford, is a mathematician. He studies the kinematics of cable laying and recovery. Cable's dynamic characteristics, ship's motion, the mountains and valleys in the ocean bottom—all must be taken into account.

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## Geology from the Air

Richard G. Ray and William A. Fischer

Aerial photographs are one of the most important tools of the modern geologist. However, it is only in recent years that aerial photographs have received extensive use in geologic mapping and exploration and that their significance as a source of geologic information has gained wide recognition.

The economic importance of aerial photographs in geologic mapping and exploration has been demonstrated many times in recent years. Noteworthy in this regard was the extensive use of photographs for geologic interpretation of the central Iranian basin, the site of one of the most spectacular oil discoveries of 1956 (1). Some years earlier, aerial photographs played a significant part in the discovery of Cerro Bolivar, the iron-ore bonanza of Venezuela (2). Today, a number of private Canadian companies are collaborating in mapping part of the Canadian Shield in one of the most extensive geologic mapping programs yet undertaken with aerial photographs (3).

Aerial photographs, when properly used in geologic work, add speed, economy, and accuracy to geologic mapping as well as certain geologic information impossible, difficult, or economically infeasible to obtain by routine field-mapping methods. These "assist" to geologic mapping are a result of many factors. Aerial photographs permit views of large areas and hence reveal to the geologist over-all geologic relationships that could not readily be seen otherwise. In addition, the geologist obtains a plan view of the terrain, similar to the planimetric presentation of geologic maps. Photographs may also show the geologic terrane in a way that it cannot be seen by the naked eye, that is, as in infrared, camouflage-detection, or other special photography; hence, geologic information is revealed that might otherwise be obscure.

Furthermore, all features, both natural and cultural, that are clearly expressed on aerial photographs can be easily measured. The accuracy of measurement depends primarily on the scale of the photography. The use of photogrammetric instruments not only permits measurements, which are important in interpretation, but also increases mapping accuracy and to a lesser extent increases the speed and economy of mapping. The degree to which aerial photographs are used varies widely, but to whatever extent photo techniques are employed, they must remain principally an aid, or tool, in geologic mapping and not a substitute for field mapping.

### Viewing the Photographs

"Vertical" photographs are most commonly used for geologic study; these are photographs taken with the camera lens pointing vertically down from the airplane. Normally, aerial photographs are taken from positions so spaced that each image within the field of the camera appears on at least two photographs. When two photographic images of the same object, taken from different positions, are combined optically by means of some sort of stereoscopic viewing device, the familiar 3-D effect is seen. The viewing device may be a simple lens stereoscope (Fig. 1), a mirror stereoscope (Fig. 2), or a precision mapping instrument such as the Kelsh plotter (Fig. 3). Aerial photographs, of course, can be studied in two-dimensional "plan view" by using single prints of aerial photographs or groups of prints mosaicked together, but the value of three-dimensional stereoscopic examination of the aerial photographs as compared with the value of examination of the two-dimensional plan view cannot be overemphasized. Whereas

conspicuous geologic features are commonly visible on single aerial photographs or mosaics of aerial photographs, the wealth of information shown in a stereoscopic view is many times greater. Details, such as fine lines or textural differences not readily seen on single photographs, or even on the ground, are commonly shown clearly in the stereoscopic model. Such clarity is in many places a direct result of the common association of fine lines and textures with relief changes, which are exaggerated in most stereoscopic models.

The value of the 3-D effect in geologic interpretation is increased by the vertical exaggeration, or relief exaggeration, that commonly occurs in stereoscopic viewing of aerial photographs. This exaggeration results from the wide spacing of camera positions at the time of exposure, as contrasted to the spacing of the human eyes; it is of particular value in interpreting the angle of dip of sloping surfaces, such as sedimentary beds, and thus low dips of 1 to 2 degrees, which may be especially significant in petroleum exploration, may be readily interpreted from the aerial photographs. In addition, minor topographic differences, which may reflect underlying geologic structure, are exaggerated and in turn may be easily recognized. The exaggeration of relief in a stereoscopic model of 1/20,000-scale photographs taken with a 6-inch-length lens is such that a geologist is enabled to differentiate differences in elevation as small as 1 foot.

### Kinds of Information

There is hardly any terrane which will not yield some geologic information from a study of aerial photographs. The amount of information naturally varies with the kind of terrane and the climatic environment.

Figure 4, showing a sequence of shales and sandstones in western United States, demonstrates convincingly the usefulness of photogeologic procedures in mapping the distribution of rock types. The clear-cut geologic contacts can be accurately mapped from photographs, thus eliminating much time-consuming effort in the field.

In a different climatic but geologically

The authors are on the staff of the photogeology section, U.S. Geological Survey, Washington, D.C.

similar area, Arctic Alaska, gently folded and faulted rocks in a potentially oil-bearing region are very poorly exposed (see Fig. 5). Differential resistance to erosion of sedimentary rock units combines with structural attitude to reveal bedding by slight topographic breaks and minor changes in vegetation type. The topographic breaks are exaggerated in stereoscopic view and permit the interpreter to detect information not readily apparent in ground study. Although the rocks do not actually crop out, the structural setting, so important to the petroleum industry, can be easily interpreted.

An extreme example of the value of aerial photographs in interpreting oil structures was a photogeologic study of the Square Lake area in northern Alaska. Fischer (4) reports that field parties have spent entire seasons within and immediately adjacent to the Square Lake area without detecting the Square Lake anticline. No outcrops are present, but small hills in the area are elongate in the same direction as the regional structural trend. Normal to this trend, other hills slope gently in a direction of postulated dip. Also, streams on the postulated dip slope have a slightly less well developed dendritic pattern than those on the opposite slope. There also seems to be a possible correlation between the slopes of the tops of cutbanks and the direction of dip. Plotting of all such data gave a consistent apparent structural pattern—a plunging anticline—of unknown reliability. A sub-



Fig. 1. Simple lens stereoscopes.



Fig. 2. Mirror stereoscope.

sequent seismic study corroborated the photo study, and test drilling in turn confirmed the photo and seismic work. In another similar terrain, photointerpretation based on minor topographic variations and stream patterns indicated a structural axis, later substantiated by seismic work (4). Drilling indicated a huge gas reservoir.

A study of heavily forested terrain of southern Alaska further indicates how aerial photographs and photo procedures may be used in geologic study and mapping. In the Prince William Sound area a detailed study of fracture systems was made, and locations of fractures were plotted with respect to fractures mapped by ground methods and known to be associated with ore deposits, primarily copper. Figure 6 shows how fractures are visible on aerial photographs even within the heavily forested areas. Such fractures are observed only with great difficulty and expenditure of effort by ground traverse. The association of certain fractures with ore deposits in turn suggests areas that might be prime target areas for ore search. Similar studies have been made in British Columbia by a leading mining company, and many square miles have been eliminated as primary target areas prior to any field study. Another leading mining company in eastern United States follows this photointerpretation technique with geophysical surveys of areas of favorable structural setting for ore deposits.

Of more subtle nature, but of considerable economic significance, is the study of patterns, particularly stream patterns, resulting from the adjustment of streams to underlying geologic structure. Even in jungle areas, invaluable data relating to structure may be obtained from aerial photographs by a technique colloquially termed "creekology," the analysis of stream pattern. Figure 7 shows how stream patterns can define a geologic structure, such as an anticline. Note how streams flow away from the suspected elongate domal structure. In other areas soil or vegetation patterns may suggest underlying structure.

It is clear, then, that aerial photographs can be an extremely useful tool in geologic mapping and exploration, but one must realize that the technique has its limitations as well as its advantages. The interpreter can only guess at the composition of rock types; he cannot identify mineral type or absolute ages of rocks, nor can he obtain such information as paleontological data.

The importance of aerial photographs in geologic study may differ with respect to the geologic terrane being mapped and the objectives to be obtained. In many studies, it would seem logical to make preliminary photogeologic studies

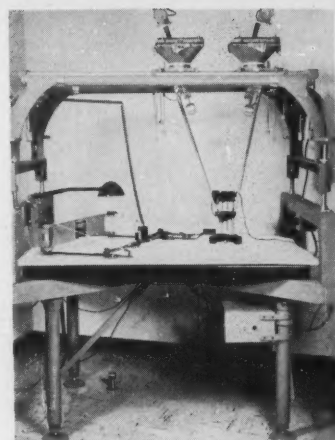


Fig. 3. Kelsh plotter, used for interpreting, measuring and plotting geologic data.

just as it is normally a preliminary step to investigate available literature before going into the field. In reconnaissance mapping, especially of remote or inaccessible areas, photogeologic procedures can be used as the principal mapping technique, and preliminary maps can be compiled solely on the basis of photo study. In detailed mapping, photogeologic procedures provide a supplemental mapping technique and assist the detailed field investigation. But, in any event, a look at photographs early in a mapping program is desirable and in certain investigations is necessary to effective follow-up study in the field. Commercial companies are relying more and more on preliminary photo study to delineate potential oil-bearing or mineralized areas in which to concentrate field investigations.

### Interpretation—Recognition Elements

Interpretation of aerial photographs is based on recognition elements—characteristics of the photograph that result from the scale selected, the color of the rocks and other elements of the terrain photographed, the kind of film and filters used, the processing of the film, and similar related factors. The most significant recognition elements for geologic interpretation are relative photographic tone, color, texture, pattern, and relation to associated features. Size and shape may also be diagnostic recognition elements in certain geologic problems.

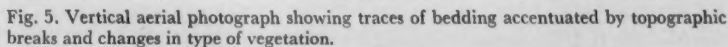
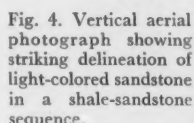
**Photographic tone.** Because of the ability of the human eye to differentiate subtle tone changes, relative photographic tone is a significant asset in geologic interpretation of aerial photographs. In areas of good exposures, bedding is characteristically recorded on the

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*Relation to associated features.* The relation to associated features is com-

**Pattern.** Pattern, or arrangement of geologic or other features, is especially significant in geologic interpretation from aerial photographs. A common use of this recognition element is the analysis of stream pattern, which may be a significant aid in interpreting the underlying geologic terrane. Patterns of joints may suggest certain rock types, or a knowledge of fault patterns of an area may be helpful in locating faults in a similar nearby terrane. Patterns resulting from particular distributions of lines are common, but a single line, or lineation, may be a special illustration of pattern. For example, a lineation may result from an orderly arrangement of stream segments, trees, depressions, or other features. This arrangement may be a con-

**Size.** The term *size*, used as a general recognition element covering all inter-





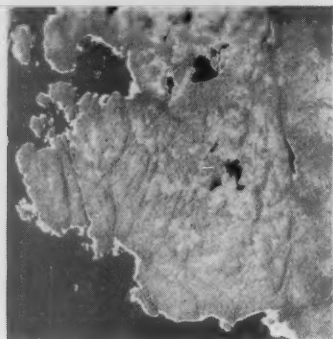


Fig. 6. Vertical aerial photograph showing fractures in heavily forested terrain.

pretation fields, is more appropriately considered in geologic interpretation in relation to thicknesses of strata, amounts of offset along faults, or other finite measurements. These measurements may be directly related to topographic expression. If the thickness of a formation is known, this knowledge may aid in identification, and determining the range in thicknesses may be essential to understanding the regional geology.

**Shape.** Shape as a recognition element in geologic interpretation is of significance primarily only in its broadest definition, involving relief or topographic expression. In this regard, it may be important for recognizing geologic features in certain areas. For example, the bold cliff face of one formation in contrast to a lesser angle of slope across an underlying formation locally may be of considerable importance in differentiat-

ing the rock units. Rectilinear depressions are expressions of faults in many areas. However, in its strictest definition, as a spatial form with respect to a relatively constant contour or periphery, shape is of little importance as a recognition element because nature may reveal the same geologic feature in an infinite number of different shapes.

### Interpretive Process

The interpretation of geology from aerial photographs involves many of the same mental and physical processes as the interpretation of geology from field observations. If the full value of the photographs is to be utilized, preliminary field reconnaissance combined with cursory study of the aerial photographs must be undertaken prior to detailed interpretation. Detailed interpretation, including measurement of features considered to be geologically significant, is then undertaken; rigorous application of the interpretive process is made in this phase of applying aerial photography to geologic study. Photographs should be used in the field not only for recording locations of observations but for contrasting geologic features with their images on the photographs to provide a basis for further interpretation. Whenever possible, geologic data derived from study of the aerial photographs should be checked and evaluated in the field.

The initial phase of the interpretive process is an observational phase wherein recognition of geologic features or characteristics of the terrain is involved. Rec-

ognition of terrain features is commonly based on combined use of fundamental recognition elements such as photographic tone and pattern. Data thus observed are then interpreted with regard to geologic significance, and the geologic history of an area is deduced, insofar as possible, from the distribution and relationships of the features recognized. Many features are expressed on aerial photographs. Sorting those features that are of significance to a particular problem and properly relating these features one to another provides a measure of the ability of the interpreter. In geologic interpretation, this ability depends primarily on the geologist's background training in geology, such as his understanding of structure and natural processes operative on the rocks, and secondarily on his experience in viewing aerial photographs. The geologist may also make use of photogrammetric instruments for making measurements, which in turn become the basis for interpretation of the geologic significance or history of an area.

Interpretation is a multistep operation, and hence a final comprehensive interpretation of the regional geology may be a synthesis of many lesser but specific interpretations, such as the direction of dip of beds in a sedimentary sequence. On the other hand, the immediate recognition of regional or large-scale geologic features as a result of the over-all aerial view, permitted particularly by small-scale photography, is commonly the basis for interpretation of smaller specific features. For example, a geologist may immediately recognize from the general land form that an area has been glaciated. This basic information would facilitate recognition of specific glacial features, such as kames and moraines.

**Example of the interpretive process.** The interpretation and mapping of the distribution of younger lava flows in an older igneous-metamorphic terrane of southeastern Alaska by W. H. Condon (5) provides an excellent example of the interpretive process in geologic study. The area has a maximum relief of slightly more than 2000 feet. Outcrops are masked almost completely by a heavy forest growth, largely coniferous trees. In poorly drained sections, a grassy swamp vegetation or muskeg has developed.

The area is underlain by highly folded and faulted phyllites, schists, and gneisses that have been intruded by granitic and dioritic igneous rocks. Younger basaltic lava flows have been extruded onto the older igneous-metamorphic complex.

Criteria used in photogeologic analysis were derived from photo study of locations where lava flows had been reported in the field. The most important criteria were based for the most part not on actual observation of the bedrock, but

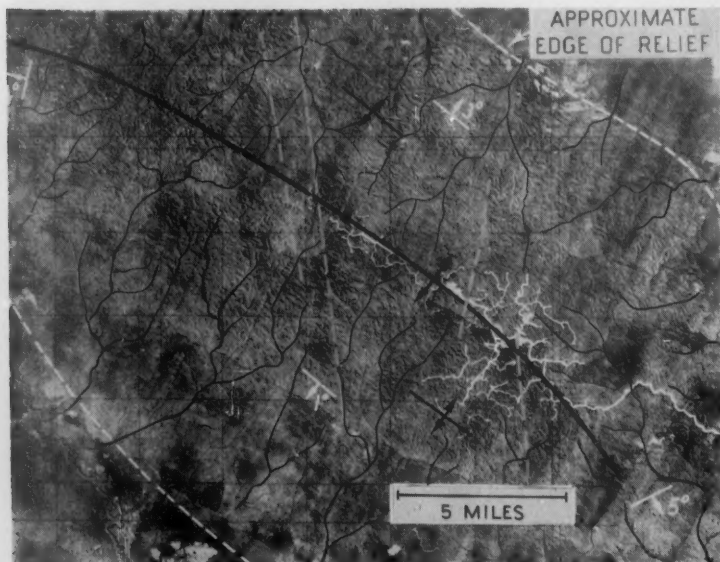


Fig. 7. Anticlinal structure in jungle-covered area, revealed by analysis of drainage pattern [Courtesy D. J. Christensen, Standard Oil Company of California]



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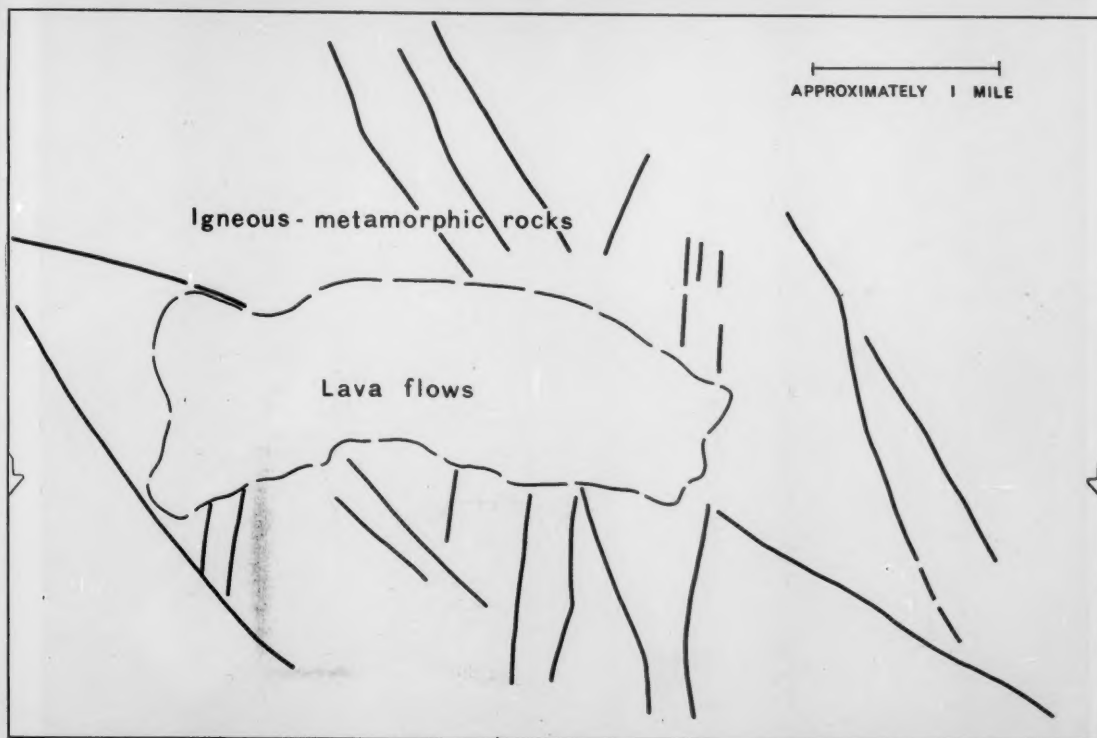


Fig. 8. (Top) Part of vertical aerial photograph showing linear features clearly expressed across ridges of older rocks but not traceable across the area occupied by lava flows. (Bottom) Index showing positions of conspicuous linear features and outline of area occupied by lava flows.



rather on the effects of rock types, structure, and geologic processes on terrain expression. These effects involve vegetation and drainage, which commonly are expressed in significant patterns. Specifically, these patterns involve (i) linear features, (ii) minor streams and abundance of small shallow ponds, (iii) density and type of vegetation, and (iv) vegetation expressed as lobate outlines by denser, darker growth. Further analysis was made for (i) the possible relation of the volcanic rocks to the pattern of probable faults, (ii) terrain forms expected in volcanic rocks, and (iii) the controlling influence of existing topography on the distribution of lava flows.

Linear features of terrain appear as long narrow gullies or troughs of varying depth and are generally well expressed in areas of the older rock complex. In many places they may be seen on aerial photographs to terminate abruptly at the edges of the younger volcanic rocks across which they cannot be traced. The pattern of linear features is most probably the expression of faults, although at least locally the possibility of joints, bedding, schistosity, or, perhaps, glacial gouging, the gross effect of which cannot be overlooked completely. Any of these possible alternate interpretations, however, would serve similarly to date the volcanic rocks with respect to the older metamorphic-

igneous complex. Figure 8 shows linear features clearly expressed across ridges of older rocks but not traceable across the intervening valley, interpreted as occupied by lavas.

Drainage characteristics and stream patterns have developed in response to the rock type, structure, and slope of terrain surfaces, and to the degree of fracturing of the bedrock. In adjusting to terrane, streams on the complexly fractured older rocks tend to be channelized to the system of linear features and to form a pattern of parallel drainage. In contrast, streams that developed on the slightly sloping surfaces of the volcanic flows, or on the steeper sides of volcanic

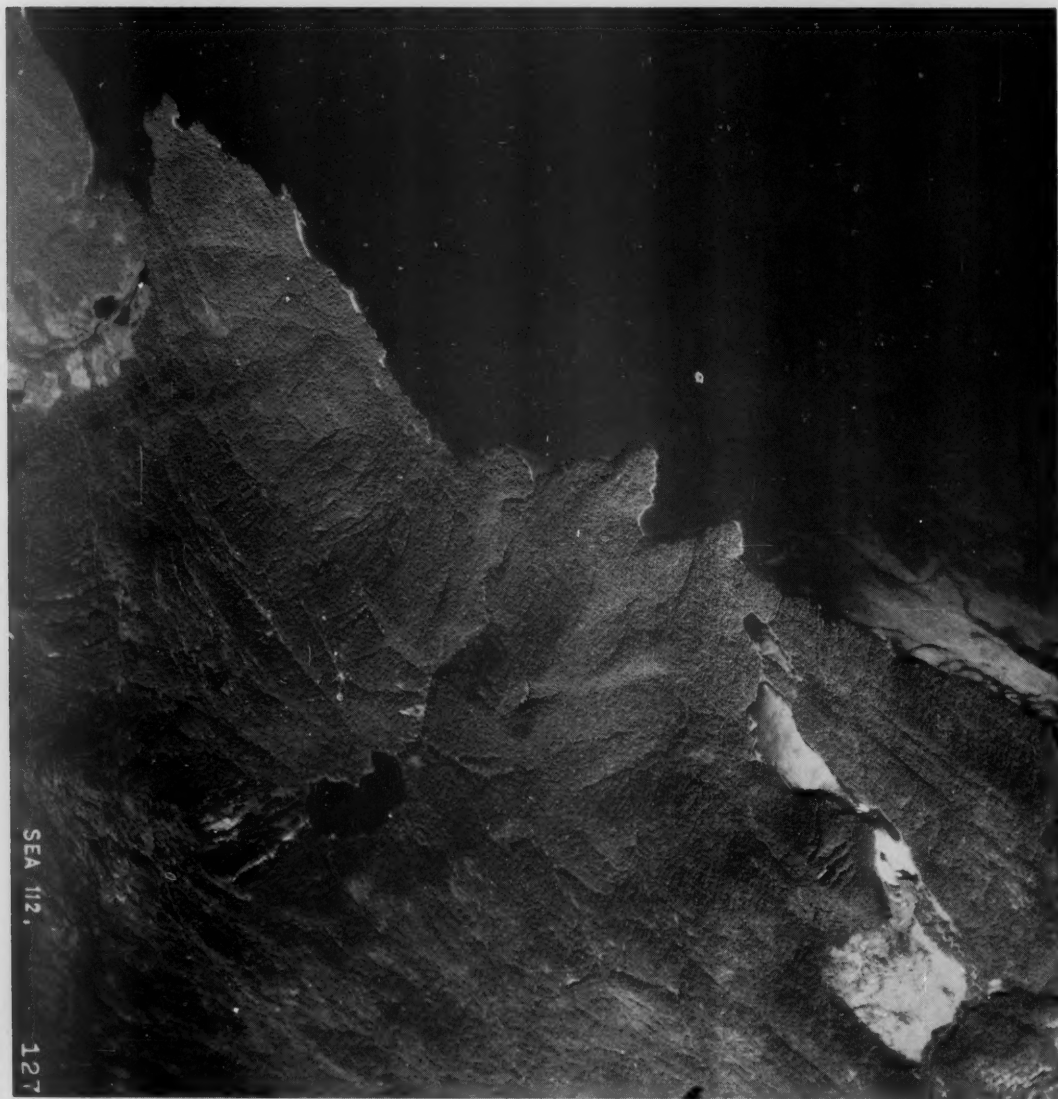


Fig. 9A. Part of vertical aerial photograph showing parallel drainage pattern of older rock sequence and radial-dendritic pattern on slopes of volcanic cone.

cones, show an irregular, somewhat dendritic or radial dendritic pattern of drainage not controlled by a fracture system. Furthermore, upon the nearly flat, poorly drained, muskeg-covered surfaces of the volcanic flows there is an abundance of small, shallow, swampy ponds not characteristic of the generally better drained surfaces of the older rock complex. Figure 9A shows the contrast of parallel drainage pattern of the older rock complex to the somewhat radial-dendritic stream pattern on the slopes of a probable volcanic cone, and Fig. 9B is an index to Fig. 9A.

The density and type of vegetation, and thus the pattern, seem to be greatly influenced by the drainage conditions of

the surface. Where drainage is good, as on the steeper slopes of volcanic cones and the generally well drained igneous-metamorphic terrane, the surface is heavily timbered with coniferous trees. Where drainage is poor, as on the nearly flat surfaces of the volcanic flows, a swampy muskeg with a sparse and patchy tree cover has developed. On these nearly flat lava surfaces a patchy vegetation pattern results from the contrast between the lighter-toned, low, grassy swamp vegetation and the taller brush and trees, which tend to be concentrated only along stream courses.

Lobate patterns of vegetation formed by dense growths of coniferous trees contrast sharply in height and in photo-

graphic tone with the low, light-toned swamp vegetation. These patterns are interpreted as marking the raised edges and fronts of the most recent lava flows, and they are particularly useful in indicating direction of flow. The development of such patterns is believed to be caused by better drainage along the raised edges of the flows in contrast to poorer drainage within the muskeg-covered central areas.

A comparison of the distribution of rocks interpreted as volcanic with the pattern of linear features in the older rocks is believed to be significant. Volcanic rocks were probably extruded along or very close to continuous and prominent linear features, interpreted as faults,

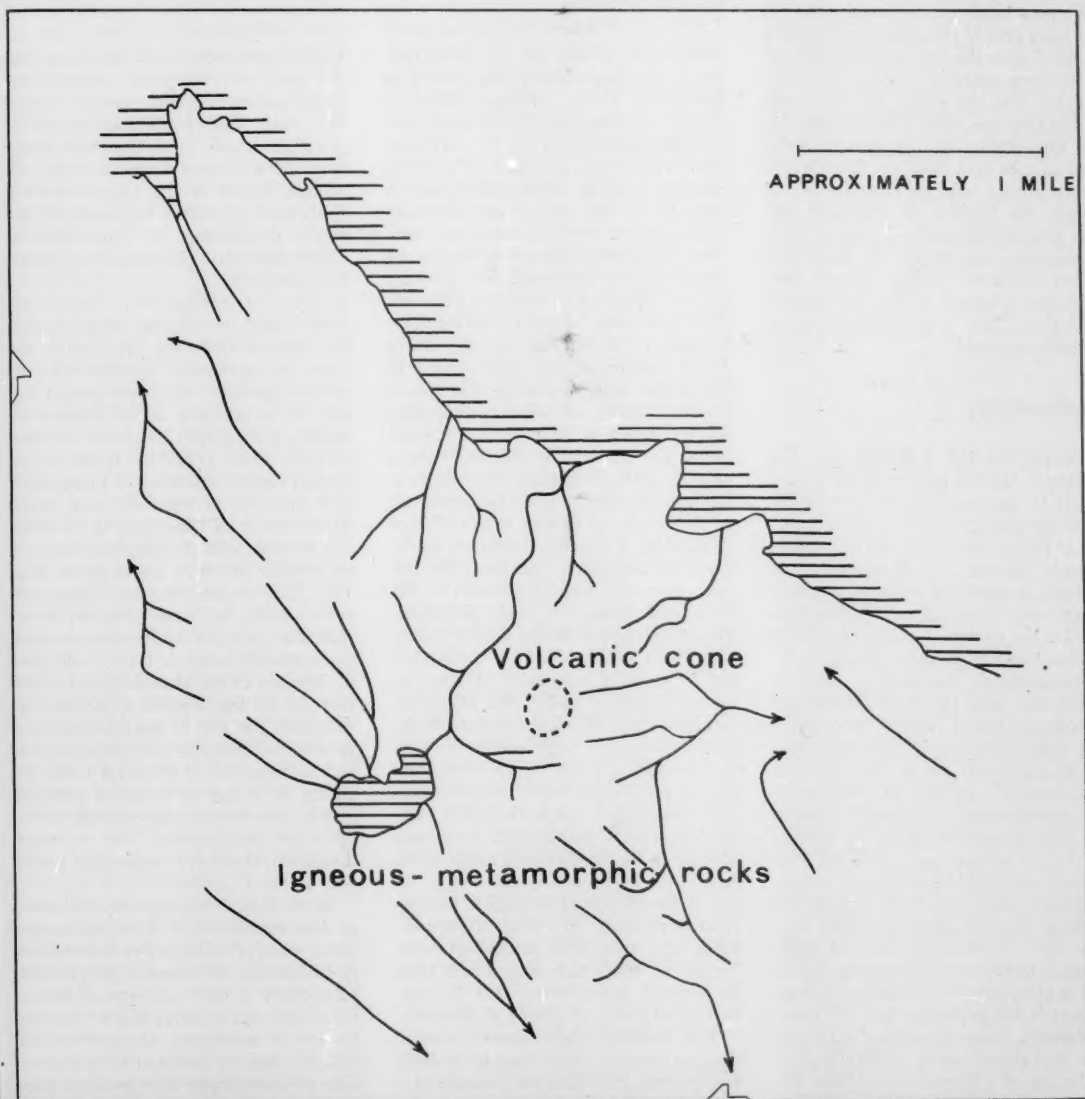


Fig. 9B. Index overlay to Fig. 9A showing contrasting stream patterns.

trending north-northeastward to northward. Along the extension of one major fault a second area of volcanic rocks was interpreted from aerial photographs. The presence of these rocks was verified in the field.

A further analysis of terrain was made for topographic features to be expected in volcanic rocks, such as remnants of cones and volcanic necks or plugs. Two sizable crescentic features were observed, one definitely a remnant breached cone, and the second probably also a breached cone.

A final consideration was made for the controlling influence of the existing topography on the distribution of the volcanic flows during the time they were being poured out on the earth's surface. Field workers in southeastern Alaska have postulated that the topography has not been greatly changed in either form or relief since the last general glaciation. It has been stated also, with some reservations, that the young volcanic rocks within this area are of late- or post-glacial Quaternary age. As seen on aerial photographs, lava flows not disturbed by glacial erosion exist on ridge slopes and occupy the bottoms of U-shaped valleys, presumably glaciated valleys. Their undisturbed appearance is anomalous within glaciated valleys, unless they were not subjected to the last general glaciation. Thus a post-glacial age is strongly suggested.

## Photogrammetry

*Photogrammetric measurements.* The important task of interpretation cannot always be accomplished by mere observation of photographs. It may be necessary to plot geologic data and to measure geologic features by photogrammetric methods in order to arrive at a sound interpretive conclusion. Photogrammetry is the science of obtaining reliable measurements by means of photography. Photogrammetric instruments used in conjunction with the three-dimensional stereoscopic model formed by overlapping aerial photographs thus provide a tool of significant use to the geologist. It is commonly possible to make necessary measurements to compile isopach and structure-contour maps of well-exposed areas without going into the area of study, although to assure best results a thorough field check of all work should be made. Isopach maps are those that show lines of equal thickness of parts of a rock formation—information that is vital in many commercial studies such as the search for petroleum and for some ore deposits. Structure-contour maps are maps that show lines of equal elevation on the top of a formation and help delineate geologic structures that may be important to the petroleum industry.

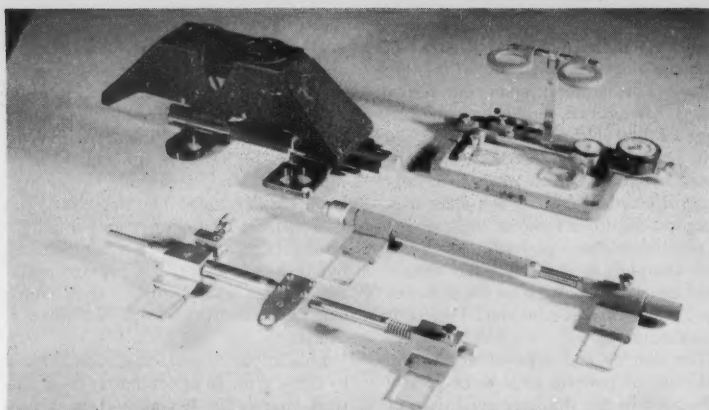


Fig. 10. Stereometers—instruments used to measure heights or altitudes from overlapping aerial photographs.

*Example of the use of photogrammetry.* An isopach-mapping project in Monument Valley, Arizona, illustrates the photogrammetric value of aerial photography in geologic study (6). In Monument Valley favorable sites for uranium minerals occur in paleostream scours or channels in the top of the Moenkopi formation. In these channels the overlying Shinarump member of the Chinle formation has thickened and provides loci of deposition of uranium minerals. The Shinarump member is particularly resistant to erosion and normally forms broad benches or the capping unit of buttes and mesas, a relation that aids in its identification on aerial photographs. By measuring a stratigraphic interval below the Shinarump member with a suitable photogrammetric instrument, it has been possible to show local thinning of the underlying rock units and inferred thickening, or channel formation, in the overlying Shinarump member. The isopach intervals—local thicknesses of the Moenkopi formation and underlying Hoskinnini tongue of the Cutler formation—were measured with a Kelsh plotter by using photography of approximately 1/20,000 scale. The Moenkopi formation and Hoskinnini tongue of the Cutler formation were measured as a unit because the base of the Hoskinnini tongue provided a more reliable structural datum, and was more readily identifiable on aerial photographs. Numerous altitude measurements were made at the base of the Hoskinnini tongue and at the top of the Moenkopi formation. Corrections were made for tilting of the rock units, and true local thicknesses were computed, which then served as a basis for isopach compilation—that is, connecting all points of equal unit thickness.

The resulting maps showed several lines, or contours, that closed in an elongate pattern, indicating the presence of a channel, possibly uranium-bearing, in the overlying Shinarump member of the

Chinle formation. It is significant that the map was compiled entirely from aerial photographs; no ground control was used. The channels delineated by photogrammetric methods agreed closely with those located by field study. Although details of the afore-mentioned study have necessarily been omitted, the results demonstrate the significance of photogrammetric procedures in geologic interpretation.

*Types of Instruments.* The instruments used in making measurements for geologic purposes are varied; the choice of instrument depends not only on the geologic objectives sought but also on a complex set of factors, including photography available, accuracy desired, time available, reliability of ground control, character of topography, and character of vegetation and cover. Measurement of differences in elevation can be made with the simple stereometer or parallax bar from paper prints (Fig. 10). These measurements are thus made economically, but some reliability of results must be sacrificed, for no correction can normally be made for tilt that may be inherent in the photography. Corrections for tilt can be made if precision instruments (see Fig. 3) are used, and thus correct thicknesses of rock units and correct altitudes can be obtained. Local accuracy of 2 feet in elevation readings may be possible with the common 1/20,000-scale photography, but accuracy throughout the entire stereoscopic model will be less than this.

As the scale of photography decreases, so does the reliability of measurements. Hence scale of photography is important in considering objectives to be attained, particularly if only one type of instrument, such as a parallax bar, is available for use in measuring. Greater over-all accuracy may be obtained from a given scale of photography with precision photogrammetric equipment (see Fig. 3) than with simpler instruments.

The procedures described may be considered as routine in using aerial photographs in geologic study; that is, interpretation is accompanied by collection of metric data which in turn may be of further use in final interpretation.

### New Techniques

In addition to these routine procedures, many new avenues of study are being tested. The new procedures involve experimentation with photographic systems, high-altitude photography, color aerial photography, new photogrammetric applications, and orthophotography (7, 8).

**Photographic systems.** Based on the premise that aerial photographic tone or color of an object should be predictable for any particular film-and-filter combination if certain factors are known, a photographic system may be devised to accomplish a specific objective, such as differentiating certain rock units. The wavelength and intensity of light reflected from a surface are the main requirements in devising a photographic system. Spectrophotometer analyses are made of the reflective spectra of rocks in question, and resulting spectral curves are used as a basis for devising a film emulsion that will differentiate the reflected light of each sample, thus recording a different photographic tone for each rock photographed.

**High-altitude photography.** High-altitude photographs taken from approximately 30,000 feet above mean terrain have been used recently with much success in geologic mapping and measurement. The three-dimensional view provided by this photography may provide the geologist with a single stereoscopic view of as much as 50 square miles. This is a much larger ground area than was heretofore covered by a single stereoscopic model. This view of a larger area enables the geologist to begin his study with a broader understanding of the relations of the general geologic features.

The advantages of extensive areal coverage in a single stereoscopic model are realized even further in the technique of using twin low oblique photographs, in which the overlap area of photographs taken at 30,000 feet flying height can cover more than 100 square miles (9). Experience indicates that in many areas, regardless of the complexity of the geology, a fundamental orderly arrangement of geologic structures can be discerned on photographs, provided that the scale is small enough. Because of the large area covered per stereoscopic model with high-altitude photographs, precision photogrammetric equipment may be used economically in some photogeologic mapping, depending on the geologic terrane and metric requirements of the job. If

camera lenses of the same focal length are used, reliability of measurement varies inversely with the altitude of the aircraft taking the photograph.

**Color aerial photography.** Recent experimental color aerial photography has demonstrated significant uses in geologic interpretation not possible with available black-and-white photography. In Death Valley, California, it has been possible to differentiate lava flows of similar color but of different ages and to differentiate certain lake sediments from lava flows, all of which appear similar on black-and-white photographs. Many of the stratigraphic units in this area have characteristic colors. When the units are in normal stratigraphic sequence, the characteristic colors are likewise arranged in a normal sequence. Interruptions in the normal sequence of colors have suggested thrust faults, later verified by field check, that were not interpreted from black-and-white photographs.

Perhaps of greater significance is the ability to differentiate some zones of alteration on color aerial photographs; these zones of alteration may be significant in mineral exploration. In a study of the Tonopah and Goldfield areas in Nevada, it was found that early stages of rock alteration could be distinguished by color and were characteristic of certain rock types. Intense alteration, however, although readily identified on color photographs, tended to produce the same color regardless of the original composition of the rock. Such intensely altered zones may well be significant with regard to ore deposition, however. With regard to color photography, it is interesting to note that the Canadians plan to "fly" the Sudbury, Blind River, and Bancroft districts with color film to determine whether clues to mineralized areas can be picked up which may guide in the search for new districts (3).

Color aerial photography in geologic study has received only limited use, presumably because of its relatively high cost compared with the cost of black-and-white photography. The high cost is ascribed by many to technical limitations of color film, such as the limited latitude in photographic conditions, the need for lenses of long focal length, and the requirement of low altitudes of flight. However, many of these limitations have been overcome in recent developments, and color aerial photography may be expected to become more competitive with black-and-white photography for purposes of interpretation. And, in any event, an evaluation of cost should logically be made in terms of results of use, as in an exploration program, and not solely in terms of the cost of black-and-white photography.

**New photogrammetric applications.** The introduction of projection-type stereoscopic plotters, such as the Kelsh,

multiplex, and ER-55 plotters, has facilitated geologic mapping and study, for the geologist uses these instruments to combine interpretation, measurement, and plotting in a mutually supporting operation. These instruments increase the accuracy and soundness of interpretation (i) by presenting the terrane in proper orientation so that features are in correct relation one to another, (ii) by allowing features to be plotted orthographically during the process of interpretation so that their relationship to features previously interpreted from adjacent stereoscopic models can be continuously studied, and (iii) by allowing measurements to be made quickly and easily so that measurement becomes a closely integrated tool of interpretation. With stereoscopic plotting instruments, isopach or structure-contour maps of some areas may be made primarily or entirely by photogrammetric means; the isopach map of part of Monument Valley, which has been described, is an example of the usefulness of photogrammetry in geologic mapping. The accuracy of stereoscopic instruments is considered particularly significant with respect to plotting features that are visible on aerial photographs but that are difficult to locate on the ground. Correct plotting of positions of features aids in their subsequent location and study in the field.

Several new instruments have recently been devised to aid in geologic interpretation. One of these is a tilting platen, or viewing surface, used with projection-type stereoplotters. The surface of the tilting platen can be made to coincide with a sloping surface in the stereoscopic model, and the angle of tilt can be directly measured with a clinometer or other measuring device. A profile plotter also has been constructed; it not only permits an accurate profile of the terrain to be drawn in any orientation of the stereoscopic model but also permits exaggeration of this profile, as desired, at the time of plotting. Another instrument is being made to measure directly the thickness of inclined rock formations shown in stereoscopic view.

It is expected that projection-type stereoplotters will be useful in geophysical studies in determining the altitudes of gravity stations and measuring the mass of the topography surrounding gravity stations for terrain correction. Statistical methods used in conjunction with the plotting instruments may eliminate many of the laborious computations of terrain corrections from topographic maps.

Some stereoplotters can be equipped with coordinate-measuring devices so that any point or object on the photograph may be located quickly in a three-dimensional grid system. Thus the photograph becomes an ideal starting point for translating positions into a



form usable in electronic computers. Furthermore, these instruments allow a model to be deliberately inclined; in this way regional dips may be introduced or removed, and the model may be studied and measured in any desired hypothetical orientation. Stereoplotting instruments provide quantitative information easily and thus allow closer integration of photogeologic interpretation with an over-all exploration program. In some areas the photographs may be the prime source of metric data.

**Orthophotography.** Orthophotography is photography that has the position and scale qualities of a map plus the abundant imagery of photographs. Conventional vertical aerial photographs are perspective views, and, in this form, all images are displaced radially from the center of the photograph. This displacement of relative position of features makes it difficult to transfer data accurately from a photograph to a map.

Figure 11 (top) is a direct copy of a part of a perspective aerial photograph; it shows the straight path of a power line as it is distorted by normal relief displacement. Figure 11 (bottom) is an orthophotograph made with a device, the orthophotoscope (10), that removes relief displacement; note that the power line is straight. An orthophotograph is in itself an excellent planimetric map; data may be transferred directly from the orthophotograph to a topographic or planimetric map. Orthophotographs also provide a means for rapidly determining altitudes in the field by reading vertical angles with an alidade, or similar instrument, and scaling the horizontal distances directly from the orthophotograph.



Fig. 11. (Top) Part of perspective aerial photograph showing distortions in power line caused by relief displacement of image points. (Bottom) Orthophotograph of the same area. Relief displacement has been eliminated in printing. Note that the power line is straight.

## Historical Summary

Flying advances in World War I were influential in stimulating aerial photography for commercial use during the 1920's. Since that time aerial photographs have been used increasingly in geologic study. One of the first important uses of aerial photographs for geologic study was in compiling mosaics, which were used for general interpretation purposes, as planning maps, and as general base maps for plotting geology. Interpretations were generally made by viewing the over-all mosaic rather than by stereoscopic inspection of photo pairs.

Subsequently stereoscopic study of photographs was undertaken in a rather extensive way, by use of simple viewing devices. Among the first important geologic interpretation studies from aerial photographs was a reconnaissance study of 35,000 square miles in New Guinea, begun in 1935 by the Dutch (11, pp. 110-117). Although the final maps were compiled by simple methods, and although positioning errors were present, the results met the requirements of reconnaissance study and demonstrated convincingly for the first time the potential of aerial photographs in a petroleum exploration program, from the standpoint both of information obtained from the photographs and of the great saving in time and money in completing the job.

Yet, no extensive use of photographs was made by the petroleum industry as a whole prior to World War II. It was only after World War II, and as a result of techniques and interests developed during the war, that the use of aerial photographs began to rise spec-

tacularly in commercial studies. Primarily the petroleum companies began extensive use of photogeologic maps, but the mining industry also indicated an increasing interest in photogeologic procedures.

Noteworthy since 1945 has been the increased use of photogrammetric instruments in compiling geologic data interpreted from aerial photographs. Although the advantages and limitations of many photogrammetric instruments have only recently received wide attention, the desirability of reliable compilation of photogeologic information has long been recognized, and the Dutch study of New Guinea in 1935 was followed by a test of the A-6 precision stereoplotting instrument for photogeologic purposes (11, pp. 115-116); plotting with stereoplotting instruments was found to have many advantages. But use of instruments lagged until after World War II. Within the past few years, however, stereoplotting instruments, such as the Kelsh and multiplex, have come into increasing use, both for interpreting and for plotting geologic data.

In a general way it may be said that use of aerial photographs in geologic study in the United States has evolved through the following stages: (i) emphasis on uncontrolled mosaics and use of single views for interpretation and plotting; (ii) use of stereoscopic pairs of prints for interpretation together with simple procedures for plotting these data; (iii) use of stereoscopic pairs of prints for interpretation together with rectification of positioning these data with simple instruments such as the radial planimetric plotter; and (iv) use of stereoscopic pairs of diapositive glass plates in precision photogrammetric instruments for interpretation and plotting. In addition, with increased use of aerial photographs in recent years, new instruments have been devised especially for geologic study, and new avenues of research are actively being pursued in interpretation studies.

The recent use of precision photogrammetric instruments in photogeologic study presages a closer integration of photogeologic and field studies. Because of the reliability of geologic measurements and positioning with precision stereoplotting equipment, a greater amount of photogeologic data may be expected to be incorporated in the geologic maps of the future (12).

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# Sexual Differentiation in Hydra

## Control by Carbon Dioxide Tension

W. F. Loomis

The chemical nature of the stimuli that control cellular differentiation may be approached with advantage in *Hydra*, for it has been shown that these animals do not differentiate sexually in response to an internal stimulus that is part of their life cycle but rather in response to an external stimulus that is controlled by the environmental conditions under which they are cultured. Although previous attempts to define the responsible variable have been unsuccessful, factors such as crowding, stagnation, nutrition, and temperature have been shown to affect the process. A few years ago we reported that *Hydra* differentiate sexually when cultured under crowded conditions such that their oxygen tension was reduced to about 70 percent saturation with air (1). Quantitative study of this phenomenon was carried out with the aid of a new and rapid method for determining dissolved oxygen (2).

### Effect of Surface/Volume Ratio

In the experiment shown in Table 1, four otherwise identical cultures of *Hydra* were grown in differently shaped containers so that the depth of the four cultures and their surface/volume ratios varied progressively. Each culture consisted of 25 *Hydra littoralis* in 25 milliliters of 70-milligram-per-liter  $\text{CaCl}_2$

and 100 milligram-per-liter  $\text{NaHCO}_3$ . The animals were grown in a beaker and three sizes of petri dishes with internal diameters of 4.8, 6, 9, and 15 centimeters, respectively. Each culture was fed for 30 minutes daily with an excess of brine shrimp larvae (3), following which it was rinsed with clean culture solution to remove all uningested brine shrimp and left at 25°C until the following day. A constant degree of crowding was maintained by the daily removal of all newly detached buds.

The results of this experiment demonstrated that, although sexual differentiation and reduced oxygen tension were parallel phenomena, they did not develop proportionally. It appeared likely, therefore, that some other volatile factor, besides oxygen, was the inducing variable. This conclusion was confirmed by the finding that artificial reduction of the oxygen tension did not induce sexual differentiation in *Hydra*.

Subsequent experiments demonstrated that *Hydra* differentiate sexually in response to an unidentified gas given off by the animals themselves (4). The rate at which this gas was secreted was found to depend on both temperature and nutrition, being especially high during periods of active digestion. Its rate of accumulation was found to vary with the depth of the water as well as with the degree of crowding and stagnation within the culture. The gas was highly volatile, for brief aeration prevented sexual differentiation from occurring in cultures that otherwise would turn sexual. Its solubility coefficient was of the order of

1, for the gas could be transmitted to the air phase and back into clean water in sufficient quantity so that it still induced sexual differentiation (Table 2).

### Air Bridge Experiment

In the air-bridge experiment (Table 2), the sex-inducing gas present in the culture water of crowded *Hydra* was transferred to an air phase and back into clean water by the following technique. Twenty milliliters of "used" culture water, obtained each afternoon from the two cultures described below, were drawn into a 25-milliliter syringe and shaken with 5 cubic centimeters of air for 30 seconds. The air phase alone was then transferred to another syringe, where it was shaken with 10 milliliters of clean water. This treated sample of clean water was given to one culture, while a similar sample of untreated clean culture water was given to the control. A constant degree of crowding was maintained by the daily removal of all newly detached buds. In this experiment, each culture consisted of 10 *Hydra littoralis* in 10 milliliters of 100-milligram-per-liter  $\text{CaCl}_2$ , 125 milligram-per-liter  $\text{NaHCO}_3$ , and 12 milligram-per-liter disodium ethylenediaminetetraacetate (Versene) brought to pH 8.0 with NaOH. Both cultures were contained in 15-milliliter beakers and fed and cleaned daily as described in the preceding section. In addition, both cultures received a second afternoon rinse about 5 hours after their daily feeding, at which time the "air-bridge" vessel received the treated water, while the control vessel did not.

Since this experiment indicated that an active gas was present in samples of air equilibrated with "used" culture water, a concentrated sample of this gas was prepared and subjected to analysis by infrared spectrophotometry, mass spectroscopy (5), and gas-liquid partition chromatography. It was found that, within the limits of these instruments, no gases were present other than carbon dioxide, oxygen, nitrogen, and argon, the carbon dioxide concentration being increased and the oxygen concentration decreased relative to their concentrations

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in normal air. Since *Hydra* actively generate  $\text{CO}_2$ , especially during periods of digestive activity (6), and in amounts proportional to their population density, it was suggested that an increased partial pressure of the unhydrated gas  $\text{CO}_2$  (" $p\text{CO}_2$ ") might be the inducing variable (7).

A convenient method for determination of  $p\text{CO}_2$  was devised. Ten milliliters of the solution to be tested was drawn up into a 20-milliliter syringe containing 10 milliliters of  $\text{CO}_2$ -free air. The syringe was shaken for 30 seconds to equilibrate the air and water phases, following which the percentage of  $\text{CO}_2$  in the gas phase was accurately measured in an improved Henderson-Haldane gas analysis apparatus (8). The  $p\text{CO}_2$  of the original sample was obtained by multiplying the percentage of  $\text{CO}_2$  found in the gas analysis by  $(1 + 1/\alpha)$ , where  $\alpha$  is the absorption coefficient of  $\text{CO}_2$  in water at the temperature of the experiment ( $20^\circ\text{C}$ ).

By using this method, a study was made of the lability of solutions whose  $p\text{CO}_2$  had been increased by the injection of water previously shaken with various concentrations of  $\text{CO}_2$  gas. It was found that brief aeration, decanting, filtering, and so forth rapidly reduced the  $p\text{CO}_2$  of such solutions to that of the surrounding air. Furthermore, it was found that undisturbed vessels such as

those described in the next section lost their increased content of  $\text{CO}_2$  gas at a logarithmic rate whose half-life was approximately 3 hours. Effective elevation of the  $p\text{CO}_2$  within such culture vessels therefore demanded twice-daily injection of a solution high in  $p\text{CO}_2$ . Using this method, it was found that *Hydra* differentiated sexually in cultures whose average  $p\text{CO}_2$  had been increased for 10 consecutive days.

### Control by $p\text{CO}_2$

Each culture in the experiment on  $p\text{CO}_2$  control of sexual differentiation (Table 3) consisted of 10 asexual *Hydra littoralis* grown in 15 milliliters of 50 milligram-per-liter  $\text{CaCl}_2$ , 100 milligram-per-liter  $\text{NaHCO}_3$ , and 50 milligram-per-liter Versene. Each culture was contained in a 15-milliliter beaker and fed and rinsed twice daily as described in the preceding section. The culture solution was shaken three times before use with a large excess of 100-percent oxygen, yielding a control solution whose  $p\text{CO}_2$  was 0.00 percent of an atmosphere (9). Water with an initial  $p\text{CO}_2$  of 8.35 percent of an atmosphere was prepared twice daily by shaking 20 milliliters of the control solution with 100 milliliters of 10-percent  $\text{CO}_2$  and 90-percent  $\text{O}_2$  in a large syringe for 1 minute. Graded amounts of this  $p\text{CO}_2$ -rich water were injected twice a day into the experimental cultures as indicated in Table 3. Care was taken to place the tip of the No. 18 needle as far under water as possible and to inject this  $p\text{CO}_2$ -rich water with a minimum of aeration. A constant degree of crowding was maintained in the cultures by the daily removal of all newly detached buds.

This experiment demonstrates that sexual differentiation may be induced in *Hydra* by artificially increasing the  $p\text{CO}_2$  of the water in which they are cultured. It confirms the fact that reduced oxygen tension is not necessary for sexual differentiation to occur, for the oxygen tension in this experiment was nearly 5 times higher than that of water saturated with air. Finally, it shows that the effects of the sex-inducing gas naturally produced by *Hydra* (air-bridge experiment) can be duplicated by using chemically pure carbon dioxide gas (Matheson).

Since increasing levels of  $p\text{CO}_2$  progressively decrease the pH of alkaline solutions, other experiments were conducted in which *Hydra* were cultured in solutions buffered with tris(hydroxymethyl)aminomethane. It was found that cultures of *Hydra* remain asexual regardless of pH when the animals are grown under uncrowded or aerated conditions. Since the experiments described in Tables 1 and 2 demonstrate that the

bicarbonate ion per se is unable to induce sexual differentiation in *Hydra*, it was concluded that the labile variable involved is  $p\text{CO}_2$ .

### Carbon Dioxide Tension

The fact that  $p\text{CO}_2$ , and not total  $\text{CO}_2$ , reversibly (10) induces sexual differentiation in *Hydra* emphasizes the difference between these two variables. The remainder of this article is devoted to a discussion of these differences, together with a brief survey of some other biological phenomena known or suspected to be specifically dependent on  $p\text{CO}_2$ .

In physical chemistry,  $p\text{CO}_2$  is defined as the partial pressure of the unhydrated gas  $\text{CO}_2$  physically dissolved in water. It differs from total  $\text{CO}_2$  in that it is concerned with only one of the four forms of dissolved  $\text{CO}_2$  ( $\text{CO}_2$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{HCO}_3^-$ , and  $\text{CO}_3^{--}$ ). Since the partial pressure of a gas is proportional to its percentage composition, the  $p\text{CO}_2$  of normal air is 0.03 percent of an atmosphere. Water in equilibrium with such air has a  $p\text{CO}_2$  of 0.03 percent of an atmosphere regardless of pH and bicarbonate concentration. Higher values of  $p\text{CO}_2$  may exist (i) in closed systems equilibrated with air containing higher concentrations of  $\text{CO}_2$ , and (ii) in open solutions that are not in equilibrium with the surrounding air and within which  $\text{CO}_2$  is steadily generated. The level of  $p\text{CO}_2$  within such open cultures depends on the dynamic equilibrium existing between the relative rates of  $\text{CO}_2$  generation on the one hand and  $\text{CO}_2$  release from the surface on the other.

Analytically,  $p\text{CO}_2$  may be determined by finding the concentration of  $\text{CO}_2$  gas that is in equilibrium with the solution to be tested (11), as in the method described in this article. Methods based on pH determinations have been described (12), but they require additional measurements of total base. Operationally, therefore,  $p\text{CO}_2$  may be distinguished from total  $\text{CO}_2$  by determining the amount of  $\text{CO}_2$  released from a solution by (i) simple shaking with air or (ii) the addition of acid.

### Factors Affecting

#### Carbon Dioxide Tension

The fact that  $p\text{CO}_2$  values above 0.03 percent of an atmosphere are possible only in open cultures which are not in equilibrium with the air makes this variable peculiarly labile. Any operation that equilibrates the culture with the surrounding air reduces its  $p\text{CO}_2$ . Thus, such seemingly gentle operations as stirring, decanting, and filtering can rapidly lower the  $p\text{CO}_2$  of a solution. In addition

Table 1. Percentage of sexual forms and oxygen tension in cultures of differing surface/volume ratio.

Depth (mm)	Oxygen tension (mg/lit)	Percentage of sexual forms after 10 days
30	7.3	100
10	8.4	100
5	8.6	48
2½	8.7	0

Table 2. Air-bridge experiment, in which the sex-inducing gas present in the culture water of *Hydra* was transferred to an air phase and back into clean water.

Day	Percentage of sexual forms	
	Air-bridge	Control
0	100	100
2	100	100
4	80	50
6	50	0
8	80	0
10	90	0
12	80	0
14	60	0
16	50	0
18	100	0
20	100	0

Table 3. Control of sexual differentiation in *Hydra* by  $p\text{CO}_2$ 

Vessel	1	2	3	4	5	6	7	8
Culture water shaken with 100 percent $\text{O}_2$ (ml)	15		14		10		5	
Culture water shaken with 10 percent $\text{CO}_2$ and 90 percent $\text{O}_2$ (ml)	0		1		5		10	
Initial $p\text{CO}_2$	0.0%		0.6%		2.8%		5.6%	
Day	Percentage of sexual forms							
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	10	0	0	0
9	0	0	10	30	70	70	70	60
10	0	0	60	50	100	100	100	100
11	0	0	70	60	100	100	100	100
12	0	0	100	60	100	100	100	100
13	0	0	100	70	100	100	100	100

tion, any variable that affects the rate of  $\text{CO}_2$  generation within a solution affects its  $p\text{CO}_2$ . Increasing the number, size, rate of respiration, respiratory quotient, and so forth of any animals within a culture tends to increase its  $p\text{CO}_2$ , while the opposite is true of photosynthesizing plants. Since  $\text{CO}_2$  may be generated indirectly by the release of acid groups in a bicarbonate solution, both glycolysis and respiration are capable at times of affecting  $p\text{CO}_2$ . In addition, any increase in the concentration of  $\text{CO}_2$  in the air affects the  $p\text{CO}_2$  of solutions open to that air, so that such apparently unrelated events as lighting Bunsen burners, working within a small, unventilated culture room, and so forth may affect the  $p\text{CO}_2$  of open cultures (13).

The subtle character of these various factors combines to make  $p\text{CO}_2$  one of the most labile and neglected of all biological variables (14). Yet increased levels of  $p\text{CO}_2$  have been shown to affect the respiratory rate and respiratory quotient of living cells, as well as the process of aerobic glycolysis (15). Krogh has shown that  $\text{CO}_2$  gas differs markedly from carbonic acid in that it can penetrate cell walls more easily than any other known substance, including water (16). Jacobs has demonstrated that this highly liposoluble gas can penetrate cell membranes selectively, thus producing intracellular acidity even in alkaline solutions (17).

The  $p\text{CO}_2$  of a solution therefore differs from its content of total  $\text{CO}_2$  as much as the  $p\text{H}$  of a solution differs from its content of total acid. Just as "acidity" today is resolved into two components—the concentration of the hydrogen ion, and the quantity of acid potentially capable of furnishing addi-

tional hydrogen ions—so "dissolved carbon dioxide" is resolvable into two components—the concentration of unhydrated  $\text{CO}_2$  molecules, and the quantity of bicarbonates and carbonates potentially capable of furnishing additional  $\text{CO}_2$  molecules. In a given solution, Henry's law states that the concentration of  $\text{CO}_2$  gas is directly proportional to its  $p\text{CO}_2$ :

$$[\text{CO}_2] = \alpha p\text{CO}_2$$

where  $\alpha$  is the solubility of  $\text{CO}_2$  gas in that solution at any given temperature (18). Finally, it is known that the amount of dissolved  $\text{CO}_2$  gas is approximately 1000 times the amount of  $\text{H}_2\text{CO}_3$  present in a solution (19) and that the solubility coefficient of  $\text{CO}_2$  in water is approximately 1 (20).

#### Known Instances of Control of Biological Phenomena by $p\text{CO}_2$

Reviewing briefly some cases where  $p\text{CO}_2$  has been shown to control biological phenomena, it need only be mentioned that the respiratory center of the brain is highly sensitive to this variable (21). Powers has pointed out that lung-breathing animals have the dual advantage of living in an environment of fixed  $\text{CO}_2$  composition and of possessing closed alveolar spaces within which the  $p\text{CO}_2$  of the air may be closely regulated (22). He stated that fish, for example, are very sensitive to the  $p\text{CO}_2$  of water, for their gills are essentially open systems and hence highly responsive to the variable  $p\text{CO}_2$  found at various depths in lakes and other bodies of water. Powers and others have held that  $p\text{CO}_2$  is a prime ecological variable, capable of

controlling both the habitats of different species of fish as well as the migratory movements of salmon (23). Davidson has recorded a striking instance of catastrophic death in fish, apparently produced by a sudden increase in  $p\text{CO}_2$  (24).

The process of photosynthesis is another biological phenomenon that is sensitive to  $p\text{CO}_2$ . Aquatic plants and algae, for example, selectively absorb free  $\text{CO}_2$  molecules rather than the almost totally impermeable bicarbonate ions (25). Thus, Emerson and Green found that at optimal levels of  $p\text{CO}_2$  (about 0.1 percent of an atmosphere) "neither hydrogen ion nor bicarbonate ion concentration influences the rate of photosynthesis between  $p\text{H}$  4.6 and 8.9" (26).

#### Possible Instances of Control of Biological Phenomena by $p\text{CO}_2$

Went and others have shown that both vegetative growth and floral differentiation in plants are highly dependent on the relative duration and respective temperatures of their day and night cycles (27). Since the primary day reaction is the  $\text{CO}_2$ -utilizing reaction of photosynthesis and the primary night reaction the  $\text{CO}_2$ -generating process of respiration, it appears possible that these effects are mediated by changes in the  $p\text{CO}_2$  of the tissues of the plant. Crocker has shown, for example, that increased concentrations of  $\text{CO}_2$  in the air regulate plant growth in a manner strikingly similar to that of ethylene chlorohydrin (28).

Several other obscure biological phenomena may well depend on this curiously labile variable. As in *Hydra*, sexual differentiation in *Protista*, *myxamoebae*, *Bonellia*, *Crepidula*, *Daphnia*, and other genera (29) would appear to depend on critically increased levels of  $p\text{CO}_2$ . Banta, for example, showed that the stimulus to sexual maturation in *Daphnia* was a nonspecific gas given off by many types of animals. Ketchell and Williams found that tissue cultures of *Cecropia* larva spermatocytes gave off a gas that induces spermatid differentiation when it is present in sufficient concentration. Whitaker has described the group effects long observed in germinating *Fucus* eggs as dependent on "a common action of hydrogen ions and  $\text{CO}_2$ " (30). Cooper demonstrated that *Rana pipiens* eggs gave off a "hatching secretion" that was inactivated on standing in the cold, as well as by simply passing it through a filter (31). Clowes described a sperm-stimulating gas derived from marine eggs (32), while Cook and Elvidge recently showed that a similar sperm-stimulating gas was given off nonspecifically by several species of *Fuaceae* eggs. He showed that this gas was chloroform-soluble and able to penetrate even



the thick walls of oogonia (33). Kisimoto found that crowding the larvae of the plant hopper *Nilaparvata* in the bottom of test tubes differentially produced flying forms of this insect, the effect varying with the degree of crowding of the larvae (34).

The extensive work of Child has shown that differentiation and morphogenesis are intimately affected by respiratory and metabolic gradients (35). It need only be mentioned here that all such gradients are, *ipso facto*, gradients of  $p\text{CO}_2$ . Bellamy observed that adding  $5 \times 10^{-5} \text{N}$  HCl to the water in which frog eggs were developing produced "a very marked acceleration of development. Both Professor Child and myself have obtained these acceleration forms independently and repeatedly" (36). Bellamy's striking results, supported by illustrations, may well be the result of a critical elevation of  $p\text{CO}_2$ , for addition of dilute acid to the carbonate-containing well water used in his experiments would raise the  $p\text{CO}_2$  in unequilibrated solutions. Merwin showed that the rate of development of frog eggs was stimulated by crowding various numbers of eggs together, as well as by exposing them to air containing 0.3 percent  $\text{CO}_2$  (37). Trinkaus and Drake reported that  $\text{CO}_2$  in the gas phase stimulated differentiation in *Fundulus* embryos (38), while Spratt concluded from similar observations in chick embryos that "it is possible that carbon dioxide may be as fundamental a requirement of the early embryo as oxygen" (39). Rather than being merely a waste product of metabolism, therefore, it appears that  $\text{CO}_2$  is capable of regulating cellular differentiation. Since the concentration of this penetrating gas is automatically highest toward the center of a mass of tissue, gradients exist from within outward that are a function of the whole, reforming whenever part of a tissue is cut away. Since these field characteristics are also those of the developing embryo, it appears possible that  $p\text{CO}_2$  gradients, generated by the cells themselves, may be one of the important variables controlling embryologic development.

Moen has shown that single cells will not grow *in vitro* unless they receive an "influence" from neighboring cells that need not be in contact with them (40). Earle and his associates were able to grow single cells in isolation by sealing them in capillary tubes filled with air that was enriched with 5 percent  $\text{CO}_2$  (41). Recently Puck has shown that single cells can be grown in media in which a "short-lived, diffusible factor" is generated by x-irradiated feeder cells (incapable of multiplication themselves) placed in close juxtaposition to the single multiplying cell (42). In all of these cases, it would appear possible that  $p\text{CO}_2$  was the mysteriously labile variable. Cer-

tainly the  $p\text{CO}_2$  within a tissue culture is generally high, for the usually alkaline culture medium is equilibrated with approximately 4 percent  $\text{CO}_2$  in the usual routine of tissue culture (43). Although the rationale for equilibrating the medium with  $\text{CO}_2$  gas is universally stated to be the establishment of a correct pH, it is clear that there are easier ways of doing this today and that this particular method may well be required for the establishment of a correct level of  $p\text{CO}_2$  (44).

### Inhibition of Growth by High Levels of $p\text{CO}_2$

The stimulating effects of low levels of  $p\text{CO}_2$  on growth and differentiation contrast with the inhibitory effects of high levels. Smith and Clowes, for example, found that cell division in marine eggs could be reversibly arrested by sufficient elevation of the  $p\text{CO}_2$  (45). Haywood and Root studied these effects quantitatively, finding that levels of  $p\text{CO}_2$  above 5 percent of an atmosphere markedly inhibited both respiration and cell division, the latter being completely arrested at about 16 percent of an atmosphere (46). Since the  $p\text{CO}_2$  of human tissues is always above 5.3 percent of an atmosphere (its level in arterial blood, 21), it appears that high levels of  $p\text{CO}_2$  may be the primary reason for the arrest of cell division in most adult mammalian tissues.

### Possible Relation to Cancer

It has been repeatedly observed that normal cells grown for long periods of time in tissue culture have a tendency to turn cancerous (47). In fact, the progressively anaerobic environment of a tissue culture apparently "provides just the conditions needed to transform the metabolism of normal epithelial cells to that of malignant cells" (48). To date, the only operative variable that has been suggested has been that of intermittent anoxia (49). Just as likely, perhaps, is the fact that the gradually increasing  $p\text{CO}_2$  within a tissue culture provides an environment favorable to the growth of any mutant cell that is even partially resistant to the inhibitory effect of high levels of  $p\text{CO}_2$ . Since variation in resistance to high levels of  $p\text{CO}_2$  is known to occur both between species (23) and within a single species (50), it may be that resistance to  $p\text{CO}_2$  inhibition can appear in cells grown for long periods of time in an environment where  $p\text{CO}_2$  is the limiting variable. Certainly any inherited resistance to  $p\text{CO}_2$  inhibition, however partial, would result in the selective growth of a resistant cell strain. Indeed, Mottram has suggested that very

high levels of  $p\text{CO}_2$  may even produce somatic mutations, for he observed that levels of  $p\text{CO}_2$  of about 10 to 20 percent of an atmosphere produced abnormal mitotic figures very similar to those produced by radiation. He concluded that "a localized increase of the carbon dioxide tension in the tissues, due to a diminished blood supply, may be an important factor in the cancerous change of cells and may even be the factor common to many known 'causes' of cancer" (51).

Whether malignant growth actually results from the *de novo* appearance of a partially  $p\text{CO}_2$ -resistant cell strain selectively capable of growing in an environment whose  $p\text{CO}_2$  is sufficiently high to inhibit the growth of its normal cell neighbors, only further work can determine.

### Conclusion

It has been found that sexual differentiation may be reversibly induced in *Hydra* by measures that control the  $p\text{CO}_2$  of their aqueous environment. The marked differences between  $p\text{CO}_2$ , or the partial pressure of dissolved  $\text{CO}_2$  gas, and total  $\text{CO}_2$  as usually measured are discussed both chemically and biologically. In general, it appears that the level of  $p\text{CO}_2$  in the environment of a living cell is one of the most labile and neglected of all biological variables, yet one that is capable of regulating both the rate of cell division and the process of differentiation.

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5. I would like to thank R. C. Gore of the American Cyanamid Company and David Rittenberg of Columbia University for these respective analyses.
6. H. M. Lenhoff and W. F. Loomis, *J. Exptl. Zool.* 134, 171 (1957).
7. I would like to thank R. K. Crane and G. H. A. Clowes for bringing the unique properties of  $p\text{CO}_2$  to my attention.
8. An accuracy of  $\pm 0.01$  percent of an atmosphere  $\text{CO}_2$  is obtainable with 10-milliliter water samples using a specially designed gas burette made to order by the Belco Glass Co., 413 N. Fourth St., Vineland, N.J.
9. Values for  $p\text{CO}_2$  are given in percentage of an atmosphere throughout this article. A  $p\text{CO}_2$  of 0.03 percent of an atmosphere is equivalent to 0.22 mm-Hg.
10. Dedifferentiation of sexually mature *Hydra* to the asexual state results from the growth of tissue downward from a growth zone around the hypostome, and not from dedifferentiation of the sexually mature cells themselves.
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## News of Science

### Sputnik

The U.S.S.R. launched the first earth satellite, *Sputnik*, on Friday, 4 October. In the United States a group of participants in an International Geophysical Year conference was being entertained at the Russian Embassy when the news was announced. Lloyd Berkner, American IGY representative who is the reporter on earth satellites for a special IGY committee, interrupted the embassy festivities to commend the Soviet scientists for their historic achievement.

In a published statement, Joseph Kaplan, chairman of the United States National Committee for IGY, said:

"I am amazed, [given] the short time which they had to plan—obviously not any longer than we had. I think it was a remarkable achievement on their part. From the point of view of international cooperation the important thing is that a satellite has been launched. They did it and did it first."

P. H. Wyckoff, another member of the United States IGY committee, commented: "We are all elated that it is up there."

The text of the first Soviet report on the *Sputnik* included the following statements:

"According to calculations . . . the

satellite will revolve at heights of up to 900 kilometers [500 miles], making one complete revolution [at 18,000 miles an hour] in one hour 35 minutes; the angle of its orbit to the equatorial plane being 65 degrees. . . .

"The satellite is in the form of a sphere with a diameter of 58 centimeters [about 22 inches] and weighs 83.6 kilograms [about 184 pounds]. It carries two radio transmitters emitting continuously signals of 20.005 and 40.002 megacycles frequency [about 15 and 7.5 meters wavelength, respectively]. The transmitters are powerful enough to insure good reception by wide numbers of amateur radio operators.

"The signals are sent in the form of telegraph messages lasting some 0.3 seconds with a pause of the same duration in between.

"The signal on one frequency is sent during the pause in the transmission on another frequency. . . .

"The Soviet Union proposes to send up several more artificial satellites during the International Geophysical Year. These will be bigger and heavier and will help to carry out an extensive program of scientific research. . . ."

Three days after the launching, Moscow radio reported that:

"The carrier rocket is just now revol-

ving around the earth at approximately the same altitude—560 miles—as the satellite. The distance between them is about 625 miles. The distance will grow."

On the morning of 8 October, Moscow radio again issued a report, this time a warning that the satellite power supply was almost expended, that its batteries had been expected to last "only a few days." Later in the day the signals were lost for a time, but reappeared as strongly as ever after a lapse of several hours.

On Wednesday, 9 October, the Soviet Union's newspaper *Pravda* published for the first time details of the satellite and its rocket:

"The successful launching of the man-made moon, has fully confirmed the correctness of the calculations . . . in designing the carrier rocket and the satellite.

"The satellite was placed in the nose of the carrier rocket and shielded by a protective cone. The rocket was fired vertically. Moving around the world now is not only the baby moon and the carrier-rocket, but the protective cone as well. . . .

"Inasmuch as the time between the jettisoning of the cone and the detachment of the satellite was not great, the rocket and the cone were comparatively near the satellite for some time. . . .

"Then, due to the difference in rotation periods arising both from the relative speeds at the time of detachment and from the varying degrees of atmospheric resistance, the three objects moved apart and in their further rotation could be spotted over absolutely different points of the world at the one and same moment.

"The altitude of the satellite varies. It changes periodically, reaching the highest point of approximately 1000 kilometers [600 miles].

"At present the orbit's perihelion [low-



est point] is in the northern hemisphere, and its apogee [highest point] in the southern hemisphere. The moon passes over the earth areas stretching approximately between the north and the south polar circles. . . . Due to resistance encountered . . . in the atmosphere's upper layer, its [elliptical] orbit will gradually take on a circular shape.

"The satellite has the form of a sphere whose body is made of aluminum alloys. All the instruments are installed inside the sphere. Before launching, the satellite was filled with the gaseous nitrogen which is forcibly circulated during the flight. This is needed to maintain the necessary temperature.

"The satellite has light sensitive elements which alter the radio frequencies of the signals and the correlation between their durations and intermissions as soon as the temperatures or other parameters of the satellite change. . . . The received radio signals are now being decoded and analyzed. . . .

"The Soviet Union will also launch a satellite having animals as passengers for the purpose of studying the behavior of living organisms during cosmic flight."

To American observers, perhaps the two most impressive facts about the *Sputnik* are its weight and the height of its orbit. The United States Project Vanguard has been hoping to launch a 21½-pound vehicle, less than one-eighth the size of the Soviet one. In addition, this country has been planning a satellite that would orbit at only about 300 miles above the earth. This altitude, roughly half that of the *Sputnik*, would touch the fringe of the atmosphere, probably limiting our satellite's life to a few days.

The Soviet accomplishment has had a significant impact on both international and domestic affairs. In the United States, there have already been demands in the press for a Congressional investigation of our missile programs. A number of high-ranking military officials in the Army, Navy, and Air Force have made public statements revealing interservice rivalry, and there has been controversy about the Federal budget allocations for scientific research (see editorial on page 723). In addition, it is predicted that long-neglected requests to the Civil Service Commission and to the White House for salary increases for Government scientists and engineers will again receive attention.

### Cole to Head IAEA

W. Sterling Cole, Republican representative of Congress from upstate New York, was elected director general of the International Atomic Energy Agency by unanimous vote of its 23 governors during the recent initial general conference in Vienna of the new organization. How-

ever, the Soviet delegate stated that the U.S.S.R. would have preferred that the agency be headed by a representative of a neutral country but that in the interests of harmony there would be no opposition to the choice of Representative Cole.

The appointment, which is effective on 1 December, will be for a term of 4 years. The recommendations of the preparatory commission to the general conference were that Cole be assisted by a staff of 370 persons. Fifteen of these would have the rank of director, with salaries of \$10,000 to \$12,500, and Cole's salary would be \$20,000.

Cole, 53 years old, has been a member of Congress since 1935 and has served on the Joint Congressional Committee on Atomic Energy since it was established in 1946; he was its chairman in 1953 and 1954. It was under his chairmanship that the basic United States law concerning atomic energy was rewritten to make it possible for peaceful uses of atomic energy to be developed more rapidly in the United States and for these applications to be made broadly available to other nations. This legislation authorized, among other things, United States activities in establishing the International Atomic Energy Agency.

Cole served as a member of the United States delegation to the conference to draft the statute of the International Atomic Energy Agency in October 1956. He also served as a member of the Congressional delegation to the Geneva atoms-for-peace conference in 1955.

### News Briefs

The Metals Research Laboratory of Carnegie Institute of Technology is observing its 25th anniversary this year with a reunion program in Pittsburgh on 24 October. The laboratory is a special research institute associated with the department of metallurgical engineering in C.I.T.'s College of Engineering and Science.

\* \* \*

October has been designated Geology Month in Scouting. As part of the month, a Boy Scout Geology Kit of program aids has been prepared by the American Geological Institute, the American Association of Petroleum Geologists, and the American Petroleum Institute, and distributed to all Boy Scout Troops and Scout Explorer Unit leaders. Many geologists have volunteered to give talks on geology, minerals, and fossils, and to conduct geology field trips during the month.

\* \* \*

San Jose State College has announced that a \$2.5-million addition to its science building has been completed for use this fall term. This facility doubles the space available for the natural sciences.

### Paperbound Science Library

*An Inexpensive Science Library*, a list of paperbound science and mathematics books, has been compiled by Hilary J. Deason, director of the AAAS High School Science Library Program [*Science* 124, 1013 (23 Nov. 1956)]. The library program is supported by the National Science Foundation.

Deason's list includes books of varying degrees of difficulty, all of which are recommended for the nonspecialist adult reader. A majority of the titles will appeal to senior high school or junior-college students, and many can be read by junior high school students.

The list, which has been published in pamphlet form, may be obtained for 10 cents from AAAS headquarters. Copies will be sent free to teachers and librarians. The books selected are as follows:

#### Anatomy

Frohse, F.; Brodel, M., et al. *Atlas of Human Anatomy*. Barnes & Noble 70, 1957. 88 pp. illus. \$2.25.

Sproul, E. E. *The Science Book of the Human Body*. Cardinal C174, 1955. 232 pp. illus. 35¢.

#### Anthropology

Alpenfels, E. J. *Sense and Nonsense about Race*. Friendship Press, 1957. 64 pp. illus. 50¢.

Benedict, R. *Patterns of Culture*. Mentor MD89, 1946. 272 pp. 50¢.

Collier, J. *Indians of the Americas*. Mentor MD171, 1948. 191 pp. 50¢.

Cotlow, L. *Amazon Head-Hunters*. Signet S1094, 1954. 239 pp. illus. 35¢.

Lips, J. E. *The Origin of Things*. Premier s33, 1956. 240 pp. illus. 35¢.

Mead, M. *Cultural Patterns and Technical Change*. Mentor MD134, 1955. 352 pp. 50¢.

#### Archeology

Albright, W. F. *The Archaeology of Palestine*. Pelican A199, 1956. 271 pp. illus. 85¢.

Cottrell, L. *The Anvil of Civilization*. Mentor MD197, 1957. 256 pp. illus. 50¢.

Edwards, I. E. S. *The Pyramids of Egypt*. Pelican A168, 1947. 256 pp. illus. 65¢.

Gurney, O. R. *The Hittites*. Pelican A259, 1954. 240 pp. illus. 85¢.

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- Scientific American*, Editors of. *The New Astronomy*. Simon and Schuster, 1955. 243 pp. illus. \$1.
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- Alexander, P. *Atomic Radiation and Life*. Pelican A399, 1957. 239 pp. illus. 85¢.
- Berrill, N. J. *The Living Tide*. Premier s26, 1956. 239 pp. 35¢.
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- Bryan, A. H., and Bryan, C. G. *Bacteriology*. College Outline 3, 1956. 422 pp. illus. \$2.50.
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Young, J. W. A. *Monographs on Topics of Modern Mathematics*. Dover S289, 1955. 416 pp. illus. \$1.95.

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Brown, H. *The Challenge of Man's Future*. Compass C3, 1956. 290 pp. \$1.25.  
Brinton, C. *The Shaping of the Modern Mind*. Mentor MD173, 1953. 287 pp. 50¢.  
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Poincaré, H. *Science and Hypothesis*. Dover S221, 1952. 244 pp. \$1.25.

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Uvarov, E. B., and Chapman, D. R. *A Dictionary of Science*. Penguin R1, 1951. 240 pp. 65¢.

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Alexander, G. *General Zoology*. College Outline 32, 1951. 290 pp. illus. \$1.50.

Bristowe, W. S. *Spiders*. Penguin K35, 1947. 57 pp. illus. 95¢.

Coombes, R. A. H. *Mountain Birds*. Penguin 67, 1952. 48 pp. illus. 95¢.

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Fisher, J. *Bird Recognition I*. Pelican A175, 1954. 191 pp. illus. 85¢.

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Fisher, J. *Watching Birds*. Pelican A75, 1951. 188 pp. illus. 50¢.

Lack, D. *The Life of the Robin*. Pelican A266, 1953. 240 pp. illus. 65¢.

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Maeterlinck, M. *The Life of the Bee*. Mentor M111, 1954. 168 pp. 35¢.

Morley, D. W. *The Ant World*. Pelican A240, 1953. 190 pp. illus. 65¢.

Peterson, R. T. *How To Know the Birds*. Signet Key KD347, 1957. 168 pp. illus. 50¢.

*Scientific American*, Editors of. *Twentieth-Century Bestiary*. Simon and Schuster, 1955. 240 pp. \$1.

### Tuberculosis

The annual report of the National Tuberculosis Association states that some 55 million people are infected with the tubercle bacillus, according to estimates based on skin sensitivity tests, and that the statistical odds are that approximately 5 percent of these, or 2.75 million people, will break down with active tuberculosis during their lifetimes if the development of active disease among the infected continues at the present rate.

The report, which has just been released, brings out that BCG, the most widely accepted vaccine against tuberculosis, cannot be employed to prevent these cases of tuberculosis because BCG is not given to people already infected with the tuberculosis germ. The report reiterates the recommendations of the NTA's medical section, the American Trudeau Society, that BCG be given to people not yet infected who are exposed to tuberculosis to an extraordinary degree, and emphasizes the importance of further research in the field of immunity to tuberculosis.

### Lalor Faculty Awards in Biology

The Lalor Foundation has announced details of the 40 awards that it is offering to college and university faculty members for research in the biological sciences for the summer of 1958. Studies employing chemistry or physics may be carried on at any institution of the award holder's choice. The upper age limit for appointment is 40 years.

The awards will usually not exceed \$900 for a single man or woman, \$1100 for a married man working at his home institution, and \$1250 for a married man whose principal program is at another institution. Transportation and other expenses are not covered.

In recent years the foundation has maintained a number of postdoctorate summer fellowships at the Marine Biological Laboratory at Woods Hole, Mass. With the consolidation of these fellow-

ships into the present program, it is suggested that those interested in work at M.B.L., and eligible under the Lalor faculty summer award plan, should submit applications under this newer program. Completed applications must be received before 14 January 1958 by the Director of the Lalor Foundation, 4400 Lancaster Pike, Wilmington 5, Del.

### ONR Astronomy Program

The Office of Naval Research has announced support for research in astronomy for the year June 1958-June 1959. Grant applications must be submitted by 15 December. Ten copies of each proposal will be required. They should include a full description of the project and a cost breakdown and should be addressed to the Chief of Naval Research, Department of the Navy, Washington 25, D.C., Attention: Code 410. Letters of recommendation will be helpful in appraising the proposals and should be sent by the writers directly to the above address.

### Scientists in the News

ROBERT W. WISSLER, who first joined the University of Chicago faculty in 1941, has been named chairman of the university's department of pathology. He succeeds PAUL R. CANNON, who retired on 30 Sept. Wissler has conducted extensive research on immunity and how it is affected by diet and irradiation. He has also shown that animals can form antibodies to destroy cancerous tissue.

The American Heart Association's 1957 Howard W. Blakeslee awards for outstanding reporting in the field of heart and circulatory diseases are as follows.

LEONARD ENGEL, free-lance writer, for his series of five articles on cardiac surgery published by the North American Newspaper Alliance, 1-6 Dec. 1956.

WALTER BAZAR, for his series of six articles entitled "New Hope for Your Heart," reporting on progress in research and advances in the treatment of cardiovascular diseases, including heart surgery. This series was published in the *New York Journal-American* during the week of 16 Dec. 1956.

DON DUNHAM, for his spot news report on the first "stopped heart" operation, which involved the use of a drug to make the heart motionless during surgery while the patient's blood was circulated by means of a heart-lung machine. The operation was performed at the Cleveland Clinic. Dunham's news story was published on 16 Apr. 1956 in the *Cleveland Press*.

STEVEN M. SPENCER, for an article entitled, "They Repair Damaged

Hearts." The article, published in the 7 Apr. 1956 issue of the *Saturday Evening Post*, gave a comprehensive review of advances in heart surgery.

"Robert Montgomery Presents," for the television program, "The Long Way Home," a 1-hour dramatization telecast over NBC-TV on 26 Mar. 1956. The program dramatized the experiences of a man who suffered a heart attack and his subsequent recovery.

Each of the winners received an honorarium of \$500. The contest year, during which entries must have been published or broadcast, runs from 1 Mar. to 28 Feb. Entries for next year's competition must be submitted by 1 May 1958.

W. PALMER DEARING, who has been serving as deputy surgeon general of the U.S. Public Health Service for the past 9 years, has been appointed to the newly created post of assistant director for health in the Office of Defense Mobilization. He is succeeded as deputy surgeon general by JOHN D. PORTERFIELD, former assistant surgeon general.

EDWARD L. GINZTON, professor of applied physics and electrical engineering at Stanford University, will receive the Morris Leibmann Memorial Prize at the national convention of the Institute of Radio Engineers in New York next March. He is being honored "for his creative contribution to the generation and useful application of high energy at microwave frequencies." Ginzton, director of the Microwave Laboratory at Stanford, is at present conducting research in Geneva, Switzerland, while on a year's sabbatical leave.

NICHOLAS METROPOLIS, who has been a leader in the development and construction at Los Alamos Scientific Laboratory of the computers known as Maniac I and Maniac II, has left Los Alamos to accept a joint appointment in the University of Chicago's physics department and Enrico Fermi Institute for Nuclear Studies. He will be professor of physics and director of the computer laboratory, where he plans to develop and build a third high-speed digital computer.

WILLIAM L. LEHMANN has been appointed head of the physics department, Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio. He succeeds WILLIAM J. PRICE, who has become senior professor of physics at the institute.

CARL R. ROGERS has been appointed professor of psychology in the department of psychology, College of Letters and Science, and in the department of psychiatry, Medical School, at the University of Wisconsin.

RICHARD L. MASLAND, professor of neurology and psychiatry and head of the neurology program at the Bowman Gray School of Medicine, has been appointed assistant director of the National Institute of Neurological Diseases and Blindness, Bethesda, Md.

Rear Admiral HYMAN G. RICKOVER, United States Navy, a leader in the planning of the nuclear submarine *Nautilus*, has won the \$8000 International Communications Prize. The prize is awarded annually during the Christopher Columbus celebrations in Genoa, Italy. Rickover was cited for "his precious and stubborn work, despite technical and organizational difficulties, to demonstrate and practically employ a nuclear generator in sea navigation propulsion."

KENNETH W. COOPER, formerly professor of biology and chairman of the department at the University of Rochester, has been appointed distinguished research professor of biology at the University of Florida, Gainesville. A cytogeneticist and investigator of insect behavior, Cooper will continue his researches in these areas.

WILLIAM G. POLLARD, executive director of the Oak Ridge Institute of Nuclear Studies, will be awarded an honorary doctor of divinity degree by Grinnell College on 27 Oct. Pollard is both a physicist and an Episcopal priest.

The Franklin Institute presented the following awards during its annual Medal Day ceremonies on 16 Oct.:

WILLARD F. LIBBY, commissioner, U.S. Atomic Energy Commission; REGINALD J. PIGOTT, consulting engineer of Pittsburgh, Pa.; and ROBERT A. WATSON-WATT, radiophysicist of Thornhill, Canada, each received a Cresson Medal.

JOHN B. JOHNSON, head of the physics department, McGraw-Edison Company, West Orange, N.J., received the Longstreth Medal.

DAVID B. STEINMAN, consulting engineer of New York, N.Y., received the Levy Medal.

The Association of American Railroads, through its president, WILLIAM T. FARICY, received the Henderson Medal.

WARREN W. CARPENTER, research consultant of Winter Park, Fla., and the Martin Company, through its vice president for manufacturing, G. T. WILLEY, each received a Wetherill Medal.

PIER L. NERVI, architect-engineer of Rome, Italy, received the Brown Medal.

WILLIAM G. PFANN, metallurgist for Bell Telephone Laboratories, Murray

Hill, N.J., received the Clamer Medal.

ROBERT M. PAGE, associate director of research for electronics at the U.S. Naval Research Laboratory, Washington, D.C., and LEO C. YOUNG, electronics consultant at NRL, each received a Balantine Medal.

HUGH S. TAYLOR, dean of the graduate school and David B. Jones professor of chemistry at Princeton University, received the Franklin Medal.

## Recent Deaths

RALPH S. BROMER, Philadelphia, Pa.; 71; professor emeritus of clinical pathology in the Graduate School of Medicine at the University of Pennsylvania; author of many books on bone diseases and radiology; 25 Sept.

FRAZIER GROFF, Bound Brook, N.J.; 62; chemist; assistant director in the Bakelite Company's development facility; formerly with Union Carbide Corporation in Cleveland; 11 Sept.

LLEWELLYN HEARD, Hammond, Ind.; 56; lecturer on science and a technical associate in the research department of the Standard Oil Company; noted for his lecture program on "Fire Magic"; 27 Sept.

LOREN C. HURD, Union, N.J.; 52; research chemist; president and director of the Metals Disintegrating Company, Inc.; on University of Wisconsin chemistry faculty, 1925-36; 28 Sept.

RUDOLPH MATAS, New Orleans, La.; 97; pioneer in vascular surgery who invented the "Matas operation" for treatment of enlargement of the veins and arteries; for 30 years chief of surgery in the Touro Infirmary, New Orleans; president of the International Society of Surgeons; the highest award in vascular surgery is named in his honor; 23 Sept.

GEORGE MERRILL, Brooklyn, N.Y.; 74; internist and allergist; associate professor of medicine at the Long Island College of Medicine; director of medicine at Caledonian Hospital in Brooklyn for 32 years; 27 Sept.

DAVID A. MYERS, San Francisco, Calif.; 82; pioneer in aviation medicine; co-inventor of the turn-and-bank indicator now used in all aircraft; 24 Sept.

OTTO RAHN, Rehoboth Beach, Del.; 76; professor of bacteriology at Cornell University, 1927-49, and then at Idaho State College until 1954; 26 Sept.

KARL SCHMIDT, Homewood, Ill.; 68; specialist on reptiles; curator emeritus of the Chicago Natural History Museum; 24 Sept.

DAVID SPENCE, New York, N.Y.; research chemist who developed important processes in the rubber field; director of research and development for the B. F. Goodrich Company in Akron, Ohio, and a cofounder of the Norwalk Tire and Rubber Company in Norwalk, Conn.



# Reports

## Volatile Saturated Aliphatic Aldehydes in Rancid Fat

A great deal of attention has been given in recent years to the isolation and identification (1) of aldehydes, ketones, and dicarbonyls in food and natural products. These compounds are recognized as influencing quality and flavor. Little is known concerning the carbonyl compounds present in rancid fats. Klose (2) found hexanal to be the major volatile carbonyl and probably the major carbonyl compound in oxidized turkey fat. A complete qualitative determination of volatile saturated aldehydes in rancid tissue fats has not been previously described. This report deals with the identification of volatile saturated aliphatic aldehydes present in rancid (3) pork fat.

Carbonyls volatilized by steam for 22 min from 10.0 g of mildly rendered (<100°C) fat were collected in an excess of 2,4-dinitrophenylhydrazine in 2N HCl. After standing overnight, the cloudy solution of 2,4-dinitrophenylhydrazones (DNPH) was extracted with carbon tetrachloride and then benzene. Chromatography on 20-percent hydrated alumina (4) yielded monocarbonyl and dicarbonyl DNPH fractions from the carbon tetrachloride and a monocarbonyl DNPH fraction from the benzene extract. The monocarbonyls from the carbon tetrachloride extract were separated into from two to four apparently different classes (5) [depending on peroxide values (1 to 86), temperature of storage, and whether the sample was cooked] on untreated Whatman No. 3 filter paper by ascending development with a petroleum ether fraction boiling at 37° to 40°C. Description of the method of separation into classes, and studies of the variations in proportions of the classes with oxidation and processing will be reported elsewhere (6). These

class fractions, on the basis of their absorption maxima in carbon tetrachloride of 343 to 346, 349 to 352, 360 to 365, and 370 to 380 m $\mu$ , appeared to be DNPH's of saturated aldehydes, saturated ketones or a mixture, 2-enals and 2,4-dienals, respectively. The dicarbonyl DNPH class had a maximum absorption at 370 to 390 m $\mu$  (6, 7).

Propanal and hexanal DNPH's have been separated and identified from the fraction with an absorption maximum at 343 to 346 m $\mu$ . The compounds were separated on Whatman No. 3 paper impregnated with 20 percent propylene glycol by ascending development with 96 percent Skellysolve C and 4 percent methanol, a rapid, new method for separating C<sub>1</sub> to C<sub>14</sub> DNPH's of saturated aliphatic aldehydes (8). Similarly, methanal and ethanal DNPH's were separated and identified in the monocarbonyl fraction from the benzene extract. This fraction was also found to contain acetone and methyl ethyl ketone DNPH's. Ethanal DNPH was isolated in two polymorphic forms. These were identified by comparison with two forms from a low-melting preparation of authentic ethanal DNPH (8).

Identification was made by comparison of  $R_F$  values with those of authentic derivatives, nonseparation on filter paper when mixed with authentic derivatives, maxima in carbon tetrachloride, fading rate in alcoholic alkali (8) of major maxima at 430 to 434 m $\mu$ , and a disappearing secondary maximum at 520 m $\mu$  which distinguishes saturated aldehyde DNPH's from saturated ketone and 2-enal DNPH's (9).

Screening of the other monocarbonyl DNPH fractions gave no indication of other saturated carbonyls. In the samples of rancid fat examined thus far, saturated carbonyl compounds with a carbon chain greater than six do not appear to be present. The chances of such compounds being mixed with other carbonyl classes seem remote since authentic higher-molecular-weight saturated compounds added to the monocarbonyl fraction separated only in the saturated class. Therefore, the separation of monocarbonyls into classes (6) is remarkably precise. The second monocarbonyl fraction with maximum at 349 to 352 m $\mu$ , which was at first thought to be a saturated ketone or a mixture of classes, is evi-

dently a separate class. Six components were found in this class; these appeared to be C<sub>8</sub> to C<sub>11</sub> carbonyls. Their spectral properties did not agree with any of the classes studied by Jones *et al.* (9); the absence of secondary maxima indicated unsaturation, but the major maxima were intermediate between saturated carbonyl and 2-enal DNPH's. It is tentatively suggested that they may be unconjugated unsaturated compounds such as have been detected in milk fat (10). The 2-enal class had five components and the 2,4-dienal class had three components that were apparently C<sub>8</sub> to C<sub>12</sub> compounds.

In a sample of unheated rancid pork fat (peroxide 86), the saturated aldehydes had the following proportions; 93.6 percent hexanal, 5.8 percent propanal, 0.4 percent ethanal, and 0.2 percent methanal. The saturated aldehyde class is the major one in uncooked rancid tissue fat. Heating at 165°C, which approximates the temperature of cooking, produces large increases in total carbonyls (11), monocarbonyls, and the proportion of the conjugated unsaturated classes (6). Ethanal, propanal, and hexanal were identified as saturated compounds lost during cooking. The predominance of saturated carbonyls in unheated fat is therefore considerably modified when the fat is cooked. Methanal was not detected in cooked fat tissue.

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3. Storage at -9.44° to -17.8°C.
4. M. F. Pool and A. A. Klose, *J. Am. Oil Chemists' Soc.* 28, 215 (1951).
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7. Maxima in carbon tetrachloride are 10 to 15 m $\mu$  lower than in ethanal or chloroform.
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22 July 1957

## Additional Trace Element Analyses of Standard Granite G-1 and Standard Diabase W-1

More and more investigators have been reporting on their analyses of various trace elements in the standard granite G-1 and standard diabase W-1 which have been described by Fairbairn *et al.* (1) and Ahrens (2) and distributed by the U.S. Geological Survey. The meth-

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

Table 1. Determination of some trace element concentrations in standard granite G-1 and standard diabase W-1 compared with the data of Smales (5). The limit of detection for Pb, Sn, Ni, Co is about 2 parts per million.

Element	Concentration (ppm)			
	W-1		G-1	
	This report	Smales	This report	Smales
Cr	105		22	
Pb	n.d.*		48	
Sn	n.d.*		n.d.*	
Zr	125		180	
Ni	110	73	n.d.*	1.0
Co	41	49	n.d.*	2.1

\* The element was sought but not detected at the level of sensitivity stated above.

ods of analysis include emission-spectrographic, chemical, x-ray fluorescence, isotope-dilution, and neutron-activation techniques. Of these, the last two generally are considered to be less susceptible to systematic errors caused by matrix effects or contamination.

This paper reports preliminary results obtained for several trace elements by an emission-spectrographic technique which utilizes the buffering action of calcium carbonate. The results on standard granite G-1 and standard diabase W-1 are presented in Table 1 and are meant to add to the accumulating data on these rocks. I make no spectacular claims for accuracy for the elements listed. I feel that the technique employed may be satisfactory in eliminating the effects of varying matrices. This technique has proved to be successful in the analysis of the trace alkaline-earths which are particularly sensitive to matrix composition (3). The method has the additional advantage that it can be extended to a wide range of geologic materials ranging in composition from pure silicates through calcareous shales to limestones.

Standards were made by mixing the metal oxides of the elements to be sought in varying amounts in an albite base. The silicate was then mixed with an equal amount of analytical grade calcium carbonate (4) which was free of the elements investigated. Correction was made for the high lead content of the albite (90 parts per million). Otherwise, the albite was also free of the elements to be sought.

The procedure of analysis is briefly the following: Five milligrams of each sample are weighed accurately to within 3 percent on a Roller-Smith torsion balance and arced to completion at 16 amp (d-c arc) in deep-cratered electrodes to avoid spattering. Kodak SA No. 1 plates are used. A set of standards is run in triplicate on each plate, and working curves are constructed directly by calculating the intensity of the line of the ele-

ment sought (with proper background corrections). No internal standard is used. The precision in most cases can be expressed as a coefficient of variation of 10 for a wide range of concentrations. The coefficient of variation increases, however, with decreasing concentration to about 25 for the range around 10 parts per million and lower. This is a common feature of emission-spectrographic analysis.

Comparisons are made in Table 1 for Ni and Co between the values obtained by the technique described above and those of Smales (5), who used the method of neutron-activation analysis. It is seen that agreement is not complete for these few samples. It is probably true that neutron activation yields more accurate results, but it is important to have all the variously determined data available. The accuracy of a technique cannot be established by comparisons of one or two samples. Turekian, Gast, and Kulp (3) use a method of assessing the accuracy of an emission-spectrographic technique for strontium determination when compared with isotope-dilution analyses. They had seven different rocks to compare.

The reasons for discrepancies in the values reported for standard granite G-1 and standard diabase W-1 among the various investigators and techniques can conveniently be broken down in the following manner: (i) errors in the analyses of G-1 and W-1 due to systematic errors (due to matrix effects) inherent in the scheme of analysis and requiring radical revision of the method to insure accurate results; (ii) errors which are due to ephemeral mistakes such as faulty standard preparation, and so forth, which may give poor results for the one or two samples analyzed. If many samples were compared, then certainly these mistakes would be discovered and rectified; (iii) the possibility of the inhomogeneity of the standard rock powders distributed. Certain trace elements have associations with particular minerals; hence any variation in the relative amounts of the latter will be reflected in the former; (iv) the "accurate" techniques of isotope dilution and neutron activation are also susceptible to systematic errors though of a different kind from those to which the emission-spectrographic or x-ray techniques are susceptible.

In light of the above situation, two suggestions can be made regarding the reporting of comparison analyses. First, the analyst using the emission-spectrographic or x-ray fluorescence technique should exercise caution in his claims for accuracy when he is dealing with complex materials such as rocks. Such claims as those of Hower and Fancher (6) for accuracy cannot go unchallenged where there are marked discrepancies between

their values and those of other reputable analysts using matrix-sensitive techniques. In addition, there are serious discrepancies with available neutron-activation values that have been reported by Smales (5).

Second, it is obvious that comparisons to test accuracy and permit interlaboratory standardization must be made on more than two samples. In the cases of standard granite G-1 and standard diabase W-1, only one figure may be available for comparison, as in the case of Pb, Co, and Ni, because the other rock is below the limit of detection for the emission-spectrograph and x-ray fluorescence methods. Hence no real judgment can be made of the validity of a technique of analysis even with the available comparisons with neutron activation or isotope dilution values.

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2. L. H. Ahrens, *Quantitative Spectrochemical Analysis of Silicates* (Addison-Wesley, Cambridge, Mass., 1955).
3. K. K. Turekian et al., *Spectrochim. Acta* 9, 40 (1957).
4. Unfortunately, analytical grade calcium carbonate is not free of strontium and barium. If these elements are also sought, a system of purification that I described in a previous article (3) must be used.
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24 May 1957

#### Potential by Ouabain of Contractile Response of Myocardium to Glucose

Ouabain increases the rate of oxidation of  $C^{14}$ -labeled glucose to  $CO_2$  by dog heart slices respiring in Krebs-Ringer phosphate medium, but is without effect on the oxidation of pyruvate (1). The significance of this observation with respect to the positive inotropic action of the drug is unknown, for no studies with contracting cardiac preparations have been reported. We have investigated the effect of ouabain on the contractile response of isolated rat ventricle strips to glucose and pyruvate and have obtained results which bear upon the afore-mentioned observations (2). Glucose is relatively ineffective by comparison with pyruvate as an energy source for rat myocardium in phosphate medium (3), and an increased rate of oxidation of the former might be expected to increase the ability of this substrate to support contractile activity.

Strips prepared from the right ven-

Table 1. Effect of ouabain on contractile response of rat myocardium to glucose and pyruvate.

Substrate	Ouabain concn. (mM)	Percentage of initial amplitude*				
		Minutes after addition of substrate				
		0	5	10	30	60
Glucose	0 (12)†	49 ± 2	36 ± 5	40 ± 5	51 ± 8	59 ± 8
Glucose	0.034 (7)	50 ± 4	57 ± 9‡	60 ± 9‡	74 ± 6‡	81 ± 6‡
Pyruvate	0 (8)	50 ± 3	61 ± 9	76 ± 14	105 ± 10	111 ± 9
Pyruvate	0.034 (6)	51 ± 4	68 ± 8	79 ± 10	97 ± 10	97 ± 14
Substrate-free control	0 (7)	51 ± 1	50 ± 2	48 ± 3	41 ± 3	33 ± 3
Ouabain control	0.034 (6)	50 ± 1	44 ± 4	40 ± 5	30 ± 5	19 ± 4

\* Mean values ± standard deviation. † No. of experiments in parentheses. ‡ Significantly different from response to glucose in absence of ouabain [ $p < 0.01$  ( $t$  test)].

tricle of the rat heart were stimulated in substrate-free phosphate medium at 27°C until the force of contraction had declined to approximately 50 percent of the initial amplitude (3). Ouabain was added at this point and, after the positive inotropic action had subsided to the 50-percent level, the substrate under investigation was added. The response was compared with that of strips to which substrate was added at the 50-percent level in the absence of cardiac glycoside. Ouabain increased the force of contraction to approximately 75 percent of the initial amplitude; the force declined again to the 50-percent level in approximately 15 minutes. This transient increase in the force of contraction produced by ouabain appeared to be related to depletion of endogenous substrates and was in marked contrast to the prolonged positive inotropic effect that occurred when the cardiac glycoside was added to slightly hypodynamic preparations (91 percent of the initial amplitude) or to ventricle strips that had become hypodynamic after prolonged contraction in a medium containing glucose. (The positive inotropic response at 37°C has been reported in a previous communication, 4.)

The responses of the ventricle strip to 5.5 mM glucose in the presence and absence of ouabain are shown in Table 1. A noteworthy difference is seen in the immediate response, with a marked depression of force within 5 minutes in the absence of ouabain in contrast to the steady increase occurring in the presence of the drug. Although the force of contraction subsequently began to increase slowly in the absence of ouabain, the value attained at the end of the experimental period was still considerably less than that attained in the presence of the drug. On the other hand, a steady increase in force which was not influenced significantly by previous exposure to ouabain occurred following the addition of 2 mM pyruvate. Results similar to those with pyruvate were obtained with 2 mM  $\beta$ -hydroxybutyrate (16 experiments).

The fact that glucose was much more effective in sustaining the contractile activity of myocardium in the presence of ouabain than in its absence is in accord with Wollenberger's findings (1). It seems clear that the conversion of glucose to pyruvate is affected in view of the failure of the drug to alter the contractile response to pyruvate or  $\beta$ -hydroxybutyrate, or the rate of oxidation of pyruvate (1). This finding provides support for the view that the positive inotropic action may be based, at least in part, on an increased energy production by the heart.

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#### References and Notes

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12 July 1957

#### Isolation and Propagation of Rabbit Kidney Epitheliallike Cells

Simplification and refinement of tissue-culture procedures during the last few years have greatly aided viral research studies. Scherer, Syverton, and Gey (1) have discussed the need for established cell strains which will support the cultivation of viruses. It is the purpose of this report (2) to describe the successful isolation and propagation of a new cell type derived from rabbit kidney tissue (strain RbK). The strain is of potential interest because of its pos-

sible susceptibility to poliomyelitis and other viral agents.

On 28 Nov. 1956, both kidneys were removed from an adult, female, New Zealand white rabbit. The capsules were removed and minced kidney cortex (1 to 2 mm fragments) was prepared in Dulbecco's phosphate-buffered saline (3). The fragments were washed repeatedly with buffered saline until a clear supernatant was obtained. A cell suspension was prepared from the minced tissue according to the simplified method described by Bodian (4). Minced tissue was treated with 0.25 percent trypsin in Hank's balanced salt solution for a total of 24 hours at 5°C and washed twice with balanced salt solution, and the cells were resuspended in 5 ml of growth medium. The latter consisted of Eagle's basal medium prepared in Hank's balanced salt solution, 20 percent rabbit serum and 20,000 units of penicillin, 5 mg of dihydrostreptomycin, and 5000 units of mycostatin per 100 ml. One-tenth-milliliter amounts of undiluted cell suspension and of a 1/10 dilution were added to 0.9 ml of growth medium in Leighton tubes; tube cultures were set up in triplicate. In addition, 1 ml of undiluted cell suspension was added to 4 ml of medium in each of two culture flasks with a surface area of approximately 24 cm<sup>2</sup>. All cultures were incubated at 37°C. Seventy-five percent of the culture fluid was renewed every third day.

Microscopic examination of the cultures showed that many cells had adhered to the glass during the first 72 hours of incubation. However, it was observed that growth progressed at a slow rate and was not stimulated by renewal of nutrient fluid. A predominance of spindle-shaped cells was seen in all cultures, and the cells were not in close apposition.

Ten days after the initial planting, the cells in the flask cultures were resuspended at 37°C in 5 ml of Hank's balanced salt solution containing 0.25 percent trypsin, centrifuged at 600 rev/min for 10 minutes, and the supernatant was discarded. After resuspension in 5 ml of growth medium, the cells were transferred to clean, sterile flasks and returned to the incubator. No enhancement of growth was observed following this treatment, and the individual cells continued to appear spindle-shaped. On the eighth day the medium was discarded from the culture flasks and replaced with growth medium containing 5 percent bovine embryo extract. The cultures received a 75-percent renewal of nutrient fluid with embryo extract every third day.

Within a week a marked growth response and alteration in cytology were noted. The cells became polyhedral, and populations of contiguous cells were es-



tablished in the flasks. Hematoxylin- and eosin-stained preparations of cells grown on coverslips in culture tubes showed round or oval basophilic nuclei with numerous mitotic figures and large amounts of cytoplasm (Fig. 1).

The dramatic change in the appearance of the cells after 5 days in medium containing bovine embryo extract (23rd day of cultivation) suggested to us that the extract definitely influenced cell transformation. A culture of the original spindle-shaped cells which was not exposed to embryo extract did not show a change in cell type and was, eventually, discarded on the 41st day of cultivation. In a recent publication by Westwood, Macpherson, and Titmuss (5) the authors discuss various phases of cell type change. They note that in their cultures of embryo rabbit kidney tissue, fibroblasts were always present when transformation occurred. Transformation occurred spontaneously between the 26th and the 65th day of cultivation and could not be induced by any specific factors in the preliminary treatment of the tissues or in the treatment of the cells at subculture.

Our strain of rabbit kidney cells was serially subcultured in Eagle's basal medium containing 5 percent embryo extract and 20 percent rabbit serum for a total of 118 days. At this time, two out of four cultures were transferred to the same medium but without the addition of embryo extract. It was found that the epithelial cell type remained unchanged after repeated passage in the absence of extract; therefore, the use of embryo extract was discontinued. At the present time, the cells are being cultivated in Eagle's basal medium, as is described at the beginning of this report. The RbK cells have undergone 37 successful passages in this laboratory and have been grown in quantity without difficulty. Sta-

tionary cultures grow as well as rotated cultures.

The susceptibility of the RbK strain to several viruses is being investigated. Preliminary results with poliovirus are encouraging. This agent has been grown serially in RbK cells through several transfers with titers comparable to those obtained in monkey kidney. Furthermore, it causes a cytopathology which manifests itself by an early clumping of the cells (1 to 3 days), followed by their rapid and complete sloughing off the glass (3 to 5 days) (6).

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6. The viral tests are being carried out by Victor Cabasso of the Viral and Rickettsial Research Division of the Lederle Laboratories, Pearl River, N.Y. It is a pleasure to acknowledge this valuable contribution to the work.

31 July 1957

### Isotope Effects in Gas-Liquid Chromatography

In view of the widespread use of gas-liquid partition chromatography, it seems timely to draw attention to the considerable changes in retention volume which may result from extensive substitution of deuterium or tritium for hydrogen in organic compounds. Such isotope effects, while they increase the difficulty of identifying labeled compounds, provide a measure of the relative vapor pressures of the isotopic compounds and may, therefore, be used to estimate the number of tritium atoms per molecule of a substance that is present in trace quantities.

Figure 1 shows the separation of cyclohexane and cyclohexane- $d_{12}$  (1) peaks obtained at 53°C with a 4-meter didecyl phthalate column and a flow rate of 45 ml (STP) of helium per minute, using a Perkin-Elmer vapor fractometer (model 154). The number of theoretical plates was calculated (2) to be about 2400. The ratio of the "apparent" retention volumes (3),  $(V'_R)_H/(V'_R)_D$ , was  $1.80 \pm 0.01$ ; this is equal to the ratio of the vapor pressures (4) at 53°C,  $p_D/p_H = 1.08$ . This is not unexpected, since it may be shown (3, p. 161) for any two substances that

$$(V'_R)_1/(V'_R)_2 = \gamma_2 p_2^\circ / \gamma_1 p_1^\circ$$

where  $p^\circ$  is the vapor pressure of the pure solute and  $\gamma$  is the activity coefficient of the solute in the stationary liquid phase. This result indicates that the relative vapor pressures of isotopic molecules can be measured by gas-liquid partition chromatography in other cases where the activity coefficients are expected to be equal.

Isotope effects of similar magnitude have been encountered in the gas-liquid chromatography of tritiated substances present in radiochemical amounts. As part of an investigation of the labeled products formed when organic compounds are exposed to tritium gas (5), benzene was irradiated by beta particles from tritium at -195°C. The products were examined using a vapor fractometer modified by addition of a small ionization chamber within the heated enclosure and in series with the thermal conductivity cell. The outputs of the thermal conductivity cell (measuring total chemical product) and of the ionization chamber (measuring tritium) were registered simultaneously on synchronized recording potentiometers.

Two of the major tritiated products were observed to have retention volumes about 5 percent and 10 percent smaller than those of cyclohexane and of methylcyclohexane, respectively. These two radiochemical products were shown to be tritiated cyclohexane and methylcyclohexane since each was removed in the same proportion (for more than 50-percent removal) as the corresponding unlabeled compound by formation of thiourea adducts (6). The magnitude of the isotope effect for the tritiated cyclohexane suggests that it contains an average of three tritium atoms per molecule. The presence of molecules containing smaller and larger numbers of tritium atoms is

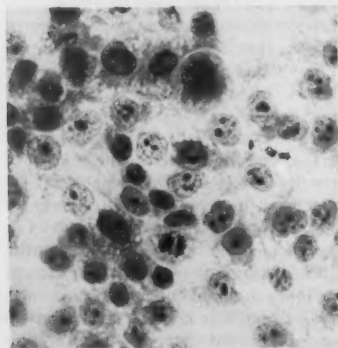


Fig. 1. Stationary culture of rabbit kidney epithelial cells from the fourth subculture in medium containing bovine embryo extract. Hematoxylin-eosin ( $\times 160$ ).

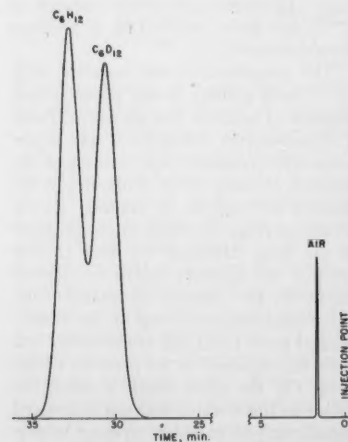


Fig. 1. Separation of cyclohexane and cyclohexane- $d_{12}$  by gas-liquid partition chromatography.



indicated by the observation that the width at half-height of the radiochemical peak is more than twice that of the corresponding chemical peak (7).

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#### References and Notes

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19 July 1957

#### Sensitivity of Hamster to Colchicine

In 1952, Orsini and Pansky (1) reported that hamsters seem to possess a natural resistance to colchicine. They found that the hamster would survive when it was injected with dosages ranging from 0.12 to 10 mg per 100 g of body weight. Upon noting this work, we undertook an investigation to discover the lethal dosage for the hamster and to note any gross effects that might occur (2).

Young mature males 10 to 12 weeks of age were used for the entire series. The animals were deprived of food for 24 hours before injection but were allowed water at liberty. The weights, dosage, and subsequent history of the animals were recorded, and all animals were injected intraperitoneally in the morning.

Several animals were injected with dosages up to 10 mg/100 g of body weight, and no outward effects of the drug were noted. At the 15-mg level, slight paralysis and loss of weight were observed. The dosage was increased to 30 mg and increased by 10-mg steps thereafter. With the 30- and 40-mg dosages, all animals displayed slight paralysis in the rear quarters, drowsiness, inability to maintain equilibrium, and a marked loss of weight. The severity of these symptoms increased with increased dosages. When given 50 to 70 mg/100 g of body weight, the majority of the animals went into a coma preceded by paralysis and surges of transient tetany, from which they did not recover. One of the animals that received 50 mg and

two of those that received 60 mg displayed severe nasal hemorrhages before death. No diarrhea or bloody stools were present, as has been reported for the rat (2). The results are recorded in Table 1.

On autopsy, pinpoint hemorrhages were present on the small and large intestines. Histological sections were made of the small intestines to observe any mitotic variation. In all cases there was a marked increase in the number of metaphase figures and an absence of spindle fibers in many cells.

Eleven males which survived the previous treatment were kept to observe any latent effects that might develop. The animals were checked, weighed, and placed with females in heat many times during the following 6 months. The males that received the 50- and 60-mg dosages never regained the tremendous weight lost, and two of the animals that received 60-mg dosages died within 3 months. Animals of these groups were hypersensitive and unsure of balance, as if their nervous or muscular system, or both, had been affected. Animals of the groups that received 30- and 40-mg dosages appeared normal and regained most or all of the weight lost.

None of the 11 males which received from 30 to 60 mg/100 g of body weight mounted a female, but all would go through the preliminary actions of breeding. However, males that received a dosage of 15 mg/100 g of body weight were fertile. Six months after the beginning of the experiment, the animals were sacrificed. In the two that had received 60-mg dosages, the following conditions were noted: the liver adhered to the diaphragm, the intestines were adhered to themselves and to the body wall, and the testes were approximately one-half of normal size. In the other groups, adhesions were not as evident and occurred only among the intestinal loops.

Histologically, the testes of these animals showed a conspicuous absence of secondary spermatocytes, spermatids, and spermatozoa. In many instances all cell types were sloughed in clumps into the lumen of the tubules. The secondary spermatocytes, spermatids, and sperm were completely absent in about one-third of the tubules of the groups that received 60 mg dosages but ranged to near normal in the group that received 30 mg dosages.

From the data given it is evident that the lethal dosage of colchicine for the hamster is approximately 70 mg/100 g of body weight. The presence of paralysis and the loss of consciousness indicate that the effects of colchicine on the nervous system are the main factor causing death. Colchicine will cause an arrest of cell mitosis in the metaphase stage in the hamster. In other work (3) the fol-

Table 1. Survival of hamsters following administration of various dosages of colchicine.

Dosage (mg/100 g of body wt.)	No. in group	Deaths		Survivals (No.)
		No.	Time after injection (hr)	
30	4			4
40	4	1	27	3
50	5	1	30	3
		1	45	
60	8	1	2	5
		1	3	
		1	108	
70	8	3	0.5	0
		2	2	
		2	3	
		1	45	
75	5	2	0.5	0
		2	2	
		1	3	

lowing is shown: (i) the effect of colchicine on the mitotic index of the crypts of Liberkuhn at the 1 mg/100 g dosage level; (ii) the optimal dosage for maximal arrested metaphases; (iii) dosages that inhibit reproduction in the female; (iv) dosages that cause resorption of the fetuses in late pregnancy (4).

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#### References and Notes

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2. Colchicine was obtained from the Nutritional Biochemicals Corp., Cleveland, Ohio.
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4. This investigation was supported in part by research grant RG4473 from the National Institutes of Health, U.S. Public Health Service.

15 July 1957

#### Alpha-Rhythm Responsiveness in Normal, Schizophrenic, and Brain-Damaged Persons

Routine examination of electroencephalographic records does not show that the electroencephalograms of schizophrenics differ in any consistent manner from those of normal patients (1). However, more active electroencephalographic techniques which introduce experimental variables in order to test for electroencephalographic changes hold more promise. Berger (2) long ago noted that sensory stimulation produced alpha blocking among normal persons. Later, Liberson (3) reported less reduction in alpha activity in response to light (a flash every 2 seconds) among catatonics than among psychoneurotics. Mundy-Castle (4) has emphasized the usefulness of more rapid photic stimulation, capable of producing alpha driving (increased amplitude or change in frequency) for

Table 1. Alpha responsiveness to stimulation.

Group	Number responding to stimulus						
	Visual	Auditory	Photic			Syn- chrony	Rest
			10-sec	20-sec	40-sec		
Normals	22	6	22	19	18	18	10
Schizophrenics	28	3	26	28	20	22	13
Brain-damaged	11	1	7	9	6	8	3

relating abnormal electroencephalograms to deviation in behavior. Consistent with Liberson's observation of reduced response in psychotics, Rubin (5) has found fewer slow-wave responses to hyperventilation among psychotics than among normals.

In a preliminary paper (6), I have described observations of consistent imagery and electroencephalographic differences in response to photic stimulation among schizophrenic, normal, and brain-damaged persons. Schizophrenics resembled organics and differed from normal subjects in their reduced responsiveness in the production of patterns, colors, and depth movement aspects of visual images. Both patient groups reported fewer felt emotions accompanying stimulation and imagery than did normals. In addition, schizophrenic and brain-damaged patients failed to show as much change in alpha rhythm, either blocking or drive, in response to photic stimulation as did the normal subjects.

The present research (7) has concentrated on repeating—with more adequate instruments and samples—the observations on electroencephalographic response to stimulation. The problem was to test the hypothesis that schizophrenics will resemble brain-damaged patients in their failure to show normal responsiveness of the alpha rhythm to visual, auditory, and photic stimulation.

The sample consisted of 24 normal subjects (mean age, 38), 20 schizophrenics on tranquilizing drugs (mean age, 39), 20 schizophrenics not on tranquiliz-

ers (mean age, 40), and 20 brain-damaged patients (chronic brain syndrome, mean age, 66). The two schizophrenic groups were roughly matched for severity of illness. Age matching, which would have been desirable (8) was not feasible for the organic group.

A Grass model III electroencephalograph machine and a Grass photic stimulator were employed. Two occipital electrodes with a lead to the right ear allowed bipolar and monopolar recording. Normal resting rhythms were established for each subject. Each period of stimulation was followed by a period of rest. The stimulation methods and the duration were as follows: 1-minute of eyes-open visual stimulation (looking at pictures); 1-minute of auditory stimulation (eyes closed listening to word association list); 30-seconds of photic stimulation at 10 flashes per second; 30-seconds of 20 flashes per second photic stimulation; 30-seconds of 40 flashes per second photic stimulation; and 1-minute of synchronized photic stimulation in which the subject's own alpha rhythm peaks served to trigger the flash.

Records were inspected to establish the responsiveness of the brain waves to each of the six stimulating conditions. In addition, responsiveness (suppression) of alpha rhythm at the onset of each rest was analyzed.

Since it has been shown (9) that the low reliability of judgments of electroencephalograms is a major problem, a second judge made independent ratings of the records on a random sample of 12 subjects (84 separate judgments). There was agreement between the two judges on 85 percent of the ratings. This is deemed satisfactory reliability.

Table 1 presents the results. Patients were categorized into those showing alpha change (drive, blocking) in response to six stimulating conditions (out of seven possible ones, including rest) and those showing responsiveness to less than six stimulating conditions. There were no significant differences between the groups with regard to the presence of normal resting alpha rhythm. The differences between schizophrenics on tranquilizing drugs and those not on tranquilizers were not significant, so the results obtained from these two groups have been combined. The Chi-square

test was applied (see Table 2). The normals showed significantly greater alpha responsiveness to stimulation than did schizophrenics ( $P = 0.05$ ). Normals showed significantly more alpha responsiveness than did organics ( $P = 0.02$ ). Differences between schizophrenics and brain-damaged patients were not significant.

Schizophrenics resemble brain-damaged patients in their lack of brain-wave responsiveness to stimulation. Tranquilizing drugs appear to have no effect on responsiveness. That psychotics are often behaviorally unresponsive to stimulation has long been clinically observed. That their brain rhythms are now found also to be unresponsive is consistent with Pavlov's claim that schizophrenia was a protective inhibition of the cerebral cortex in the face of excessive traumatizing bombardment with stimuli. It is also consistent with more recent findings (10) which demonstrate the existence of a reticular excitatory center important for arousal and behavioral response to sensory stimuli. It has been shown (11) that this reticular region is subject, to some extent, to influence from the cortex.

One can surmise that in schizophrenia there are actual changes in brain function which closely resemble the states produced by demonstrable pathology in organic patients. The changes in schizophrenics appear to consist of a reduction in cortical responsiveness to external stimulation, possibly owing to the inhibition of afferent input in the reticular arousal centers. Whether or not the apparent inhibition of input in schizophrenics represents metabolic or tissue pathology in the excitatory center, or whether it represents learned inhibition through cortical influence, remains unknown (11).

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20 June 1957

Table 2. Chi-square categories.

Group	No.	No. responding to 6 or more stimu- lus conditions	No. responding to 5 or less stimu- lus conditions
Normals	24	11	13
Schizophrenics on tranquilizers	20	3	17
Schizophrenics not on tranquilizers	20	4	16
Brain-damaged	21	1	20

## Detection of Chromatographic Spots in Paper

Many substances which show no fluorescence or phosphorescence at room temperature do so on cooling. Accordingly, it was found that many substances which give no visible chromatographic spots do so if the paper is cooled in liquid nitrogen. The method of detection consists of simply dipping the paper into liquid  $N_2$  and then viewing it in the dark in near-ultraviolet light. Since the paper itself becomes weakly phosphorescent under these conditions, spots can also be detected as dark areas if the substance in question quenches the phosphorescence of the paper. Many substances show an afterglow.

If no liquid  $N_2$  is available, Dry Ice can be used in some cases. The paper is placed in a glass cylinder so that it touches the glass. The cylinder thus formed by the paper is then filled with crushed Dry Ice, and the paper is then viewed without removing it from the container.

This method of detection has the advantage that it does not entail the chemical alteration of the substance to be tested. The color and intensity of the phosphorescence may help in identification.

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9 August 1957

## Pink Discoloration in Eggs Caused by Sterculic Acid

Pink discoloration of eggs during cold storage is associated with the feeding of cottonseed oil or cottonseed meal to laying hens. This discoloration is a result of the combination of conalbumin of the white with ferrous ion of the yolk to form a pink complex (1). Increased permeability of the vitellin membrane allows diffusion of proteins and water into the yolk. Reverse diffusion of the complex into the white accounts for the pink color of the white. The yolk enlarges and becomes apricot-colored as a result of the blending of the pink color with the natural yellow of the yolk. The causative

agent present in cottonseed has not been positively identified.

Lorenz (2) first observed that the component causing pink discoloration of eggs and the component responsible for the Halphen reaction (3) might be identical. The Halphen test is used to identify cottonseed oil since no other common oils give a positive test. Several uncommon oils, such as Kapok seed oil and *Sterculia foetida* oil, are also known to give a positive test. Kapok seed oil also causes pink discoloration of eggs. The fatty acid composition of *S. foetida* oil was investigated recently. In addition to minor quantities of oleic, myristic, and palmitic acids, this oil contains a large proportion (70 percent) of an unusual  $C_{19}$  acid called sterculic acid (4). The structure of this acid (I) was first elucidated by Nunn (5). Verma *et al.* (6) disagreed with this assignment and proposed structure II. Other evidence supporting structure I has been presented by Faure (7, 8), who has shown also that pure sterculic acid gives a positive Halphen reaction (Fig. 1).

In this laboratory *S. foetida* oil (9) has been fed to laying hens and found to cause pink discoloration of eggs. When the *S. foetida* oil was hydrogenated sufficiently to eliminate double bonds but not to disrupt the cyclopropane ring structure, it did not cause pink discoloration. Six individually caged White Leghorn laying hens were divided into three groups and fed *ad libitum* for 15 days. The feed was the usual complete ration mixed with or without *S. foetida* oil in corn oil as follows: group I, 1.5 percent corn oil; group II, 1.5 percent corn oil and 0.09 percent *S. foetida* oil; and group III, 1.5 percent corn oil plus 0.09 percent hydrogenated *S. foetida* oil. At the end of 1 month of storage, the eggs were opened. The eggs from groups I and III were all normal, while seven of 11 eggs from group II showed definite pink discoloration.

Sterculic acid is the major constituent fatty acid in *S. foetida* oil. It is known that the other component fatty acids do not cause pink discoloration of eggs. Sterculic acid is, therefore, apparently responsible for the increase in permeability of the vitellin membrane which leads to pink discoloration of eggs (10).

*Note added in proof:* In a subsequent experiment, pure sterculic acid,  $n_D^{25.8}$

1.4632 [ $n_D^{24.8}$  1.4643 (8)], prepared by the urea complex method of Nunn (5) was fed to White Leghorn laying hens. Six individually caged birds were divided into three groups and, in addition to the basal ration, were fed daily by pipette the following: group I, 1 ml of corn oil; group II, 1 ml of corn oil and 0.10 g of pure sterculic acid; group III, 1 ml of corn oil and 0.025 g of pure sterculic acid. After 1 month of cold storage, eggs from groups II and III showed definite pink discoloration, while eggs from Group I were normal, thus confirming the conclusion that sterculic acid causes pink discoloration of eggs.

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9. The oil was extracted from seeds provided through the courtesy of F. R. Amos, director of forestry, Manila, Philippines.
10. This report is Arizona Agricultural Experiment Station technical paper No. 430. This work was supported in part by the National Cottonseed Products Association, Inc.

8 July 1957

## Rapid Symptoms in Seedling VII Sweetpotato of a Virus Always Associated with Internal Cork

The rapid mechanical transmission of a virus (1) consistently associated with sweetpotato cork virosis to Scarlett O'Hara morning glory (2) opened up a new approach to study of this virus by reducing the incubation period from about a year on sweetpotato to a week on the morning glory. This discovery posed the possibility of finding a sweetpotato plant that would respond as promptly as the morning glory with distinctive symptoms to the same method of inoculation.

After numerous transmission experiments in 1955, there was no doubt that the same mechanical technique transmitted the virus from sweetpotato or other susceptibles to the various sweetpotato varieties and seedlings under test, but the expression of symptoms in sweetpotato was poor, and the incubation

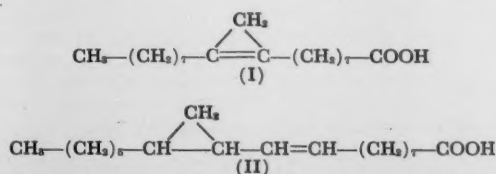


Fig. 1. Structures of sterculic acid proposed by Nunn (I) and by Verma *et al.* (II).



period was longer than a month. Besides, the rapid indexing technique revealed that practically all the sweetpotato varieties in our collection were virus-contaminated. This was checked and verified by the "flush of growth" technique in the greenhouse and by the "surge of growth" technique in the field (3).

In the search for a satisfactory sweetpotato indicator plant, the first problem was to find virus-free clones. Since practically all the commercial sweetpotato varieties are virus-infected, the next step was to examine and study seedling clones. Seeds of the Porto Rico-type sweetpotato were obtained from the Agricultural Experiment Stations of Louisiana and Georgia for this purpose. Thirty such seedlings tested in 1955 were found to be virus-free, but none was satisfactory as an indicator plant.

In 1956 over 300 seedlings were produced and tested. The seeds were from open-pollinated Porto Rico plants grown in Louisiana and Georgia. To expedite this work, we used only graft transmission. Of several methods of grafting, the "chip-bud" method (4) was found to be superior and it was adopted as standard practice in these studies. Again, all the seedling clones were found to be virus-free.

In two experiments involving 129 seedling clones, one designated as clone VII (from seed from Louisiana) exhibited clear-cut chlorotic spot leaf symptoms 3 weeks after it had been grafted with diseased buds; in contrast, longer periods were required for all other clones of seedlings and of the named varieties that

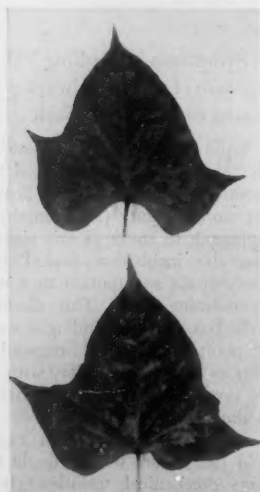


Fig. 1. Chlorotic spot symptoms of a virus associated with internal cork on sweetpotato clone VII (bottom) 24 days and (top) 12 days after mechanical inoculation by the rapid transmission method.



Fig. 2. A stab-graft at the end of 24 days. The graft was of a healthy clone VII shoot on a diseased Porto Rico root. Chlorotic spot symptoms had begun to show on the new growth 17 days after grafting.

were tested. The clones had been grown for 2 months in 4-in. pots and then pruned back to eight nodes and transplanted to 6-in. pots at the time of "chip-bud" inoculation.

Following this discovery, a third experiment was set up involving clone VII and a mechanically inoculated Scarlett O'Hara morning glory check, both replicated five times. Chip-buds were placed at the third nodes, and the sweetpotato plants were pruned back to the fourth nodes to stimulate a spurt of growth.

Chlorotic spots appeared on the new growth from the buds in the axils of node 4, beginning on the seventh day and becoming more distinctive later. Figure 1 illustrates these symptoms on the 12th and 24th days. The mechanically inoculated Scarlett O'Hara check also showed typical vein-banding mottle on the seventh day and vein-clearing by the 12th day.

Another experiment compared the merits of the graft and mechanical methods of inoculation of clone VII, with Scarlett O'Hara as a check, when diseased clone VII was used as the source of inoculum. The grafted plants showed symptoms on the seventh day, as in the previous experiment, but clone VII and Scarlett O'Hara, when inoculated mechanically, showed no symptoms until the 11th day. The delay in symptom expression following the latter method of inoculation was attributed to the probability that sweetpotato clone VII con-

tained less virus than did infected plants of Scarlett O'Hara which had been used in previous experiments.

The fifth experiment tested the mechanical method of inoculation on clone VII plants having five leaves unfolded and on the Scarlett O'Hara check. This time, three sources of cork virus were tested in triplicate on three conditions of plants of clone VII: (i) plants unpruned, (ii) plants with two leaves removed, and (iii) plants with four leaves removed. The bottom leaf was inoculated in all cases. The three virus sources were sweetpotato clone VII, Scarlett O'Hara containing virus isolated from symptomless Nema gold sweetpotato roots, and Scarlett O'Hara containing virus from Porto Rico roots with symptoms of internal cork.

On the seventh day, symptoms of vein-banding began to show on Scarlett O'Hara plants that had been inoculated with inoculum 3. These symptoms became more marked with time. On the same day, symptoms produced by inoculum 3 were most advanced on the unpruned clone VII plant, but they were also present on the plant that had had two leaves removed. With inoculum 1, the Scarlett O'Hara check showed the first vein-banding symptoms on the 21st day, a week later than the appearance of chlorotic spots on clone VII. Thus, clone VII appeared to be equal to if not better than Scarlett O'Hara as an indexing host when small amounts of inoculum were present. In all cases, the shock of removal of all but the inoculated leaf (the standard procedure for Scarlett O'Hara) interfered with early symptom expression on clone VII. The removal of two leaves caused a short delay in symptom expression. The unpruned clone VII plants, with five leaves, were in a good growth status for the prompt appearance of symptoms.

Clone VII has been found valuable in other studies on internal cork. Scions of clone VII, when stab-grafted (5) into suspected diseased sweetpotato roots, demonstrated the presence of virus by positive chlorotic spot symptoms on the first new scion growth (Fig. 2). Clone VII also proved to be excellent for use in insect transmission experiments. It served just as well as Scarlett O'Hara in aphid transmission studies (6).

In conclusion, these studies revealed clone VII (a sweetpotato seedling from open-pollinated Porto Rico seed from Louisiana) as an excellent indicator plant or indexing host for the virus associated with internal cork whether used in mechanical, graft, or insect transmission experiments.

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## References and Notes

1. The virus under investigation is one that has been found constantly associated with root and foliage symptoms of internal cork disease. This sweetpotato virosis received its name from the root symptom phase. Studies are in progress to determine the relationship of associated symptoms such as leafspot, chlorotic spot, ringspot, chlorotic ringspot, purple ringspot, feather, and oak-leaf with the typical root symptoms.
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4. A chip of diseased stem tissue with a bud in the middle, and measuring about  $\frac{1}{2}$  in. in length, was removed with a sharp razor blade and transplanted to an identical position on the healthy plant stem. It was held in place by a  $\frac{1}{2}$ -in. strip of Stericrete rubber.
5. With a scalpel, vertical stab wounds are made in the upper end of a sweetpotato root. The root is bedded upright in sand. Into each wound a snug-fitting, wedge-shaped scion is inserted. The scions usually establish vascular connections in 7 to 10 days.
6. E. M. Hildebrand, in preparation.

28 June 1957

## Bone Crystallites as Observed by Use of the Electron Microscope

In 1949 Wolpers (1) observed, by use of an electron microscope, that the mineral portion of bone consists of needle-shaped crystals 30 to 60 A wide and 400 to 1000 A long. However, later electron microscopic studies by Robinson *et al.* (2) indicated that bone crystals are hexagonal platelets having average dimensions of 500 A long by 250 A wide by 100 A thick. Robinson's concept has been accepted by most workers in this country for several years. In 1953 Schwarz and Pahlke (3) interpreted electron micrographs to indicate that the calcareous (mineral) deposits in bone are spindle-shaped particles 150 to 1300 A long. From 1953 to 1957 Finean and Engstrom (4) presented evidence from x-ray diffraction studies indicating that bone contains rod-shaped, apatite crystallites 40 to 75 A wide and about 200 A long. Recently, Fernandez-Moran and Engstrom (5, 6) observed a predominance of rod- or needle-shaped apatite particles 30 to 40 A wide and about 200 A long in electron microscopic studies of undecalcified bone sections (human, rat, hen, and fish).

Electron microscopic studies of bone have been made in this laboratory (7).

Sections (6  $\mu$  thick) of frozen-dried, methacrylate-embedded, undecalcified bone were obtained by routine methods (8). These were re-embedded in methacrylate with the desired orientation and sectioned at 90° to the plane of the 6- $\mu$  section. Satisfactory sections were obtained by using a diamond knife (9) in a Porter-Blum microtome (10). The sections were mounted on a grid coated with a carbon membrane and examined, using a 100-kv beam in an RCA EMU-3 electron microscope. The thickness of the sections was nominally 250 A. However, for best results it was necessary to study selected areas which may have been somewhat thinner than the average section thickness.

Inspection of many sections of normal, mature, cortical bone taken from humans and dogs showed an abundance of rod-shaped particles situated in groups or bundles in the plane of the section (Fig. 1). In other sites they appeared to be less regularly arranged, probably because of their oblique orientation. From considerations of relative densities, these are considered to be the inorganic crystallites. These crystallites were about 50 A thick and ordinarily 600 to 700 A long. Occasionally longer (about 1200 A) and frequently shorter (down to 200 A) particles were seen. Because the lengths of the particles may be several times the thickness of the section, it is apparent that the significance of these values (especially the smaller ones) is open to question until a method can be devised to demonstrate that the particle lies in, and not oblique to, the plane of the section. The volume occupied by the mineral component, from considerations of ash weights and densities of the organic and mineral components, is approximately 40 percent, a figure which is generally compatible with the appearance of these electron micrographs. The remainder of the volume is composed of areas of lower electron density in which the periodic banding that is typical of collagen fibers could sometimes be observed.

More recently it has been possible to section unembedded cortical bone, thus allowing examination shortly after sacrifice of the animal and without previous chemical treatment. Preliminary studies of such sections have shown structures

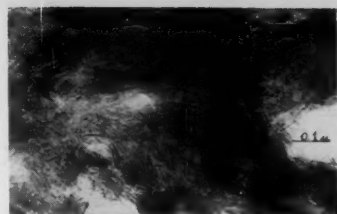


Fig. 1. Electron micrograph of a section of undecalcified cortical bone from the mid-shaft of the femur of an adult dog. The section shown is parallel to the long axis of the bone.

indistinguishable from those described above for sections embedded in methacrylate.

These electron micrographs are interpreted to show that the crystallites of bone are rod- or needle-shaped structures and not hexagonal platelets as reported by Robinson *et al.* (2). Fernandez-Moran and Engstrom (6) reported evidence of fine structure within these rod-shaped particles. However, our studies so far have failed to support this observation. Currently we are investigating the relationship of these crystals to the organic fibers of bone.

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6. —, *Biochim. et Biophys. Acta* 23, 260 (1957).
7. This work was performed under the auspices of the U.S. Atomic Energy Commission.
8. L. A. Woodruff and W. P. Norris, *Stain Technol.* 30, 179 (1955).
9. The diamond knife was made available through the kindness of H. Fernandez-Moran.
10. The technical assistance of O. T. Minick of the Electron Microscope Laboratory is gratefully acknowledged.

5 August 1957

## Book Reviews

**Automation in Business and Industry.**  
Eugene M. Grabbe. Wiley, New York;  
Chapman & Hall, London, 1957. 611  
pp. Illus. \$10.

In the spring of 1955, an engineering extension course on automation was held by the University of California. This consisted of a series of lectures by eminent scientists, engineers, and industrialists. It proved to be a success, and consequently the lectures, some 70 in all, have now appeared in book form.

The book has all the advantages and disadvantages of its origin. Many of the individual contributions are fresh and informative—each facet of the subject is treated with authority by an acknowledged expert. On the other hand, they are uneven in length, depth, comprehensibility, and importance; there is much repetition. In spite of, and partly because of, the lack of coherence inherent in such a compilation, an excellent impression is given of the complexity and rapid growth of the subject.

The term *automation* is not one which marks precisely the limits of a particular field of development. This can be seen from the attempts of quite a number of the authors of the essays which comprise the book to define it in accordance with their own conceptual needs. In the present instance the bias is toward computer and feedback control, but there is very little left in the book of the original "Detroit" automation concept, based essentially on the transfer machine.

The term *automation* has now been accepted internationally, even if grudgingly. In Europe, where the subject is at present fashionable, there is hardly a speaker on the subject who does not begin his lecture by deploring the word, both for its linguistic impurity and for its lack of precise meaning; yet no alternative has been seriously proposed.

There are many, too, particularly among the engineers, who dismiss automation as being overdramatized and not new. This may be so, but there is a really substantial rate of development and there is great industrial interest in each of the three main groups of technical advance which loosely comprise automation—refined mechanization, automatic control, and the use of electronic computers;

what is not yet clear is how quickly it will be possible to integrate these three streams of progress to provide a fully automatic production system.

The present book, while it pays lip service to the fuller concept of automation, naturally—since it is the work of specialists—concentrates on the component advances and does so clearly and well. For example, there is an excellent summary by John L. Bower of the development of digital control of machine tools, while Dean E. Wooldridge, in discussing the "future of automation," points out the lessons to be learned from military electronics and weapons-system experience. There are excellent descriptions, too, of analog and digital computer developments, of data processing, and of instrumentation, process, and industrial control. The sections on the petroleum and chemical industries, by C. G. Laspe, describe clearly how significant the application of these methods has already become. He goes a little too far, perhaps, in his introduction, where he states that "automation has been the key to the rapid growth of the present-day process industries." Surely this is more true in reverse; it has been the high state of science and technology in the chemical and petroleum industries and the development of continuous processes and of long runs of production which have favored development of advanced instrumentation and feedback control, much to the benefit of industry as a whole.

It is becoming increasingly clear that we are now at a stage in technological advance at which fundamental scientific knowledge and the existence of techniques in electronics and other fields should make great and dramatic advance possible in the near future. As Simon Ramo says in the first chapter of the book: "There are scores of aids to business and industry and transportation that present technological art is capable of providing, without a single new discovery in basic science. It would be possible today on the basis of known pure science to design devices that could displace a very large fraction of the white-collar workers." Again, at the end of his essay, he writes, "Perhaps the most glaring shortcoming of today's art is our lack of quantitative understanding of human

beings as part of a complete system which includes both the machine and the human being."

Herein lies the real problem of automation. The basic science exists in sufficient degree to produce completely new patterns of industry; engineering skills are available (although scarce) to exploit the new possibilities, but men are not yet sufficiently aware of the nature of the changes and of the adjustments which will have to be made. The real problem of automation is this individual and social comprehension. The increasing complexity of automation is, in particular, a challenge to management, from whom is demanded a knowledge of, or at least a familiarity with, problems of vastly differing nature—economic, engineering, and human. We know far too little about the changes that automation will bring to the industrial and social structure, but they will certainly be profound, and evidently rapid and healthy progress can be made only if technical, economic, social, and educational facets are dealt with as a whole. Automation is thus an excellent pilot example of the rapid technical change which is characteristic of our age. The problems it brings will, to a large extent, be common to other types of advanced technical innovation, including atomic energy. It is important, therefore, that they should be studied.

The present book recognizes these wider problems but devotes little attention to them. As an account of the individual techniques which are creating true automation, it is, however, excellent and is to be widely recommended.

ALEXANDER KING  
*European Productivity Agency, Paris*

**Isotopic Tracers in Biology.** An introduction to tracer methodology. Martin D. Kamen. Academic Press, New York, ed. 3, 1957. xii + 474 pp. Illus. \$9.50.

This is the third edition of a work which was first published in 1947 under the title *Radioactive Tracers in Biology*. In the intervening 10 years the use of tracers has become commonplace, and the literature, even in a specific field such as biology, has become so voluminous that the author has made no attempt to produce an exhaustive survey of the field. In selecting more recent work, Kamen judged the pedagogic value of the study, rather than its novelty, as a criterion for inclusion in the text.

Among the significant changes in the new edition are the inclusion of chapters on stable isotope tracers and a revision of the early sections dealing with the physics of the nucleus and the chemistry of radioactive ions. Specific parts of this

volume dealing with biochemical applications have been greatly extended. The third edition also contains a series of very useful appendixes, the one on chromatography being particularly noteworthy in its detailed description of the use of autoradiographic techniques as a means of augmenting the information that can be obtained from the original paper chromatogram.

HERMAN YAGODA

*National Institute of Arthritis  
and Metabolic Diseases*

**Report of the Conference on Recent Developments in Cloud-Chamber and Associated Techniques.** Comprising collected papers of the conference held under the joint auspices of the Physical Society of London and University College, London, March 1955. N. Morris and M. J. B. Duff, Eds. University College, London, 1956. 227 pp. Illus. 30s.

This volume is composed of the papers presented at the Conference on Recent Developments in Cloud-Chamber and Associated Techniques, held in London in 1955. There are 46 papers, plus reports of six discussion sessions. The reports cover the following variations of cloud chambers: diffusion, multiple plate, high pressure, fast cycling, and pure vapor. Problems of measurement and interpretation of tracks and apparatus for reprojection and measurement were discussed in one of the sessions (five papers). Circuits, counters and apparatus used for counter-controlled operation, and other peripheral matters are taken up in a number of papers. The bubble chamber, which was quite new on the scene at the time the conference was organized, was accorded a short presentation. However, because of the rapidity with which the development of this device has proceeded in the last few years, the material given in the report can now be considered to be only an introduction to the subject. Most of the authors are from laboratories in England, but there is a good representation from the United States and other countries.

It would be pretentious to try to rate the contents of the volume—its contributors constitute a large fraction of all the practicing experts in the cloud-chamber business, and it is therefore authoritative by definition. As in any report of a conference, the value of the written version depends on the care with which the manuscripts were prepared and assembled—the standard set by the editors. In the preparation of this volume, the editors are to be commended. They have been thorough in gathering the pertinent written material, references, and discus-

sion. What is even more commendable in a work of this kind, they have made sure that the graphs and pictures are accompanied by full captions.

In the volume at hand we have without doubt the most complete statement existing on the art of cloud chambers. It is so complete, in fact, that one cannot help wondering, with a little nostalgia, if this will be the treatise to end treatises on the subject. In the past decade or more we have seen large sections of the area of usefulness of the cloud chamber taken over by the counter, the photographic emulsion, and the bubble chamber. It is easy to extrapolate and think that possibly before very long the displacement will be complete. There are, however, at least two areas which come to mind in which the cloud chamber still holds its position: (i) counter-controlled operation (preexpansion tracks), especially as applied to the study of cosmic rays, and (ii) the study of low-energy particles, particularly where it is desired that the tracks be long enough so that their curvatures in a magnetic field can be measured. Bubble chambers at present cannot be counter-controlled because no way has been found to produce expansion within the lifetime of the activation produced by the moving particle, and they are not suited to the study of low-energy particles because of the high stopping power of the liquid. Photographic emulsions obviously cannot be counter-controlled, and they have limitations similar to those of the bubble chamber where low-energy particles are concerned. These examples are enough to show that, in spite of a narrowing of the field, there do remain applications for the cloud chamber which are not challenged by the other techniques. Perhaps, therefore, the present excellent volume of reports does not have to be considered a swan song.

Everyone working with cloud chambers or concerned with the interpretation of cloud-chamber results will find the volume very interesting and valuable.

H. R. CRANE

*University of Michigan*

**Psychological Aspects of Aging.** Proceedings of a Conference on Planning Research, Bethesda, Md., April 24-27, 1955. John E. Anderson, Ed. American Psychological Association, Washington, D.C., 1956. 323 pp. \$2.

This is a significant book which can be read with profit not only by those specifically interested in problems of aging but also by graduate students and others entering research in any field of scientific psychology or the social sciences. The conference which it reports was held

under the auspices of the American Psychological Association and was financed by the National Institute of Mental Health. Its purpose was to survey the field of possible research on aging that might be made by different branches of psychology.

The book begins with the text of the opening address by J. H. Sheldon, who was at the time president of the International Congress of Gerontology and to whose untiring efforts to foster international cooperation in this field, the invitation to give this address was a fitting tribute. The papers which follow are divided into five sections. The first deals with personality changes during the adult years and their relation to social adjustment. The second considers the nature of, and means of assessing, age changes, mainly from a psychophysiological standpoint. The third section outlines the more strictly psychological studies of changing ability, measured in the main by so-called "mental" tests. The fourth section discusses problems of training and education in the light of changes, with age, in the capacity to learn and of shifts in the pattern of motives brought by older people to their tasks. The fifth section is a consideration of age changes as they affect employability. There follows a masterly summary and ordering, by the editor, of proposals for future research raised by the other contributors.

As is evident from the scope of the various sections, the papers are representative of many different branches of psychology, and their scientific quality varies with that of the branch from which they have come. Almost all are, however, of high standard within their own fields.

The book as a whole would seem to be important for four reasons. First, it makes clear that psychological studies of aging during the adult years are now developed to a point at which they merit serious attention, both from psychology generally and from other branches of science.

Second, the papers as a whole provide an accurate view in research terms, without sentimental distortions, of the field as it must be considered by psychologists intending to enter it. Anyone who has attempted the difficult task of doing research on aging will know that a man often takes 2 or 3 years to become oriented and to begin making his own contribution. The present book should enable him to form a quick appraisal of the kind of work that has been done and of the areas in which contributions are now required, and thus it should give him a flying start and a better perspective than his predecessors have enjoyed.

Third, there is a repeated insistence on the need to view aging as a continuous process over the whole life-span. Most discussion in the past has been con-



cerned with the limited problems of old people past retirement age. The contributors here give reasons for emphasizing that this period of life is but one part of a continuous development and that studies are therefore needed throughout the adult years as a complement to the extensive knowledge we already possess of childhood and adolescence.

Fourth, and perhaps most important, the outlook of the contributions makes them a concise example of a tendency in psychological thought which is returning to prominence after some years of relative disfavor. The statements have a certain refreshing directness and "elegance" in their approach to the study of human behavior. The sterile arguments of so-called "learning theory," the doctrinaire half-truths of the "schools," the panacea treatments of "systems," and the high-sounding, empty technical terms often found in psychological writings are conspicuous by their absence.

The book is essentially a guide to future work rather than a record of past findings. It is like a stiff *aperitif* which promises a fine meal to follow. How far this will be realized depends, as more than one contributor pointed out, on the provision of research support. I venture to disagree with the editor when he suggests that this can well be given in the form of short-term grants. Research on aging will attain the standards and the quality of mind displayed by the contributions to the present symposium only if substantial permanent opportunities are accorded for work in this field.

A. T. WELFORD

Cambridge University

**Ageing in Industry.** An Inquiry, Based on Figures Derived from Census Reports, into the Problem of Ageing under the Conditions of Modern Industry. F. Le Gros Clark and Agnes C. Dunne. Philosophical Library, New York, 1956. 150 pp. \$7.50.

As stated in the subtitle of the book, this is "an inquiry into the problems of ageing under the conditions of modern industry" in Great Britain. The purpose of the study is to determine, as far as possible, the number of workers physically able to continue in their various occupations beyond their middle 60's. Tables on age and occupation published in the *Census Reports* for 1921, 1931, and 1951 are the basis for the study.

Thirty-two occupations were selected for analysis. These included about 25 percent of the male workers in 1951. Most of the report is devoted to a detailed study, from the viewpoint of the older worker, of the occupations and of a representative number of modern industries.

The concluding chapter groups the occupations according to percentage of "survival rates." These represent the percentage of men considered to be physically capable of remaining at their accustomed occupations into their late 60's and beyond. These findings are qualified on the basis of conditions prevailing in modern industry and do not presume to reflect new methods which could make a profound difference.

The report has been written on a practical level and provides an interesting comparison of a wide variety of occupations, conditions of work, and opportunities for modifying the work process and the retirement practices. While few positive conclusions are drawn, challenging possibilities have been revealed which can lead to a growing appreciation of the capabilities of the older worker.

WILLIAM C. FITCH

Special Staff on Aging, U.S. Department of Health, Education, and Welfare

**Limited War.** The Challenge to American Strategy. Robert Endicott Osgood. University of Chicago Press, 1957. xi + 315 pp. \$5.

Robert E. Osgood, in *Limited War*, undertakes to cast some light on the problem which currently confronts American leadership—namely, if the present nuclear stalemate has made total war less likely, how does one limit and fight the wars which may still occur? He attempts to do this primarily by the use of historical material, some old and some very recent. While maintaining that Americans traditionally have been pacific yet pugnacious, he states that we have never understood the proper relationship of power to policy or, in Clausewitzian language, how to use the military as an instrument of national policy. The Communists, on the other hand, have an excellent understanding of the relationship of means to end, or of force to policy. The theme of this book is the power-policy relationship, an understanding of which Osgood considers essential to a solution of our current problems.

In a section entitled "The Lessons of History," he attempts, on the basis of the very scanty historical research in this field, to show the factors which have limited wars in the past. He argues that political, social, and moral restraints accounted for the limited wars of the 18th and 19th centuries, the French revolutionary era excepted. Statesmen sought to attain only limited objectives, while social, economic, and technological considerations limited the capabilities of nations for waging war. Furthermore, no ideological conflicts raged, and this made possible a calmer approach to interna-

tional conflicts. The 20th century saw an end to these old restraints and an improvement in the national capacity to wage war. From Osgood's account, it is not entirely clear to what extent the limitation lay in the nature of society and to what extent it was wilfully imposed by enlightened statesmen.

This book is primarily concerned with events that occurred and problems that arose after World War II. The author accepts the containment of communism as a valid national objective but states that more than the concept of massive retaliation is necessary for its achievement. The Indo-China crisis is cited to show the shortcomings of this concept as an instrument of policy as well as to reveal the difficulties of waging limited war in that area. The Korean war—an agonizing experience in limited war for the United States—is discussed at some length, but the analysis of the reasons for its limitation is superficial and disappointing.

While the book provides many helpful insights and asks pertinent questions, it leaves the reader feeling a bit frustrated. The questions do not probe as deeply as they might, and there is too much superficial treatment of important aspects of the problem. The notes reveal that the author might well have read more than he did of the appropriate civilian and military periodical literature on the subject. However, this is a courageous and useful work on a very complex subject.

GEORGE K. TANHAM

Rand Corporation

## Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

*Beach Erosion Board, Bulletin.* vol. 11, No. 1. 62 pp. *Effect of Bottom Roughness on Wind Tide in Shallow Water.* Tech. Memorandum No. 95. 31 pp. *Factors Affecting Durability of Concrete in Coastal Structures.* Tech. Memorandum No. 96. 50 pp. *Hurricane Wave Statistics for the Gulf of Mexico.* Tech. Memorandum No. 98. 95 pp. *Laboratory Study of the Effect of an Uncontrolled Inlet on the Adjacent Beaches.* Tech. Memorandum No. 94. 19 pp. Beach Erosion Board, Corps of Engineers, Washington 25, 1957.

*Bibliography of Medical Reviews.* vol. 2. National Library of Medicine. Public Health Service, Washington, 1957 (order from Supt. of Documents, GPO, Washington 25). 111 pp. \$0.60.

*A Review of the Rockfishes of California* (family Scorpaenidae). State of California, Fish Bull. No. 104. Julius B. Phillips. Department of Fish and Game, Marine Fisheries Branch, 1957. 158 pp.

*Specific and Intraspecific Delimitation.* C. G. G. J. Van Steenis. Botanic Garden of Indonesia; Foundation Flora Malesiana, c/o Rijksherbarium, Leyden, Holland, 1957. \$2.50.



# Meetings and Societies

## American Bacteriologists

The 57th general meeting of the Society of American Bacteriologists was held 28 Apr.-2 May at the Sheraton-Cadillac and Statler hotels in Detroit, Mich. The attendance was approximately 2000, and 420 individual papers were presented in addition to numerous symposiums and round tables.

The meeting opened with a general address by A. A. Mossel (Utrecht, the Netherlands) on "The science of the interrelation between food and micro-organisms." On the second day a symposium on "Microbial aerosols and respiratory infections" was convened by LeRoy D. Fothergill (Fort Detrick, Md.). Techniques and equipment were described and illustrated which make possible the exposure of experimental animals to aerosols of highly infectious organisms with complete safety to operating personnel. The optimum infection response was confirmed to be with particles in the size range of 1 to 5 microns in diameter.

Thomas C. Grubb (Vick Chemical Company) presided at a symposium on "Antimicrobial preservatives." Problems of testing the effectiveness of preservatives and selection of preservatives were discussed. The very timely subject of laboratory diagnosis of virus infections was covered in another symposium, convened by Gordon C. Brown (University of Michigan). Particular attention was given to the role of the public health laboratory in diagnosing virus diseases.

Milo Appelman (University of Southern California) led a symposium on "Problems in the microbiological analysis of foods." Methods of analysis, standards, educational aspects, sampling, indicator organisms, and other phases were discussed. Other symposiums covered such topics as antiseptic and disinfectant testing, preparation of samples for microbiological assay, spore germination, and cell fragments.

Many outstanding and significant papers were presented to the general sessions of the society. In the field of viruses, Cora Downs and associates (University of Kansas) reported the successful cultivation of *Rickettsia akari* in lifeless medium. In a similar vein, Dean Fraser and H. R. Mahler (Purdue University)

discussed the synthesis of bacteriophage by protoplasts of *Escherichia coli*, and Sol Spiegelman (University of Illinois) reported protein synthesis by noncellular preparations from bacteria. The latter two papers were part of the symposium on "The role of cell fragments in metabolic reactions."

Contact transmission of poliovirus among monkeys was announced by Don Craig (University of Michigan). Workers from Merck, Sharp and Dohme, the University of Southern California, and Parke, Davis and Company reported studies on measles virus which may lead in the near future to an effective measles vaccine.

Various aspects of the use of fluorescent antibodies for the identification of bacteria were discussed by Carrie C. Winter (Communicable Disease Center, U.S. Public Health Service, Atlanta, Ga.), John D. Marshall, Jr. (Armed Forces Institute of Pathology), and Charles H. Carter (Fort Detrick). The rapid identification of organisms of similar morphology by means of two dyes of contrasting color and the use of labeled antirabbit globulin were described.

A novel application of the principle of continuous-flow culture (chemostat) was reported by Leonard Zubrzycki and Earle Spaulding of Temple University. These workers were able to establish "steady-state" growth of human fecal flora and to use the method for study of microbial ecology.

The cell wall of the yeast phase of *Histoplasma capsulatum* has been shown to be composed of chitin. This was reported in a well-documented paper by Edgar Ribi, Bill Hoyer, and Granville Goode (Rocky Mountain Laboratory, Hamilton, Mont.). X-ray diffraction and electron microscope studies showed a distinct similarity to fibrils of regenerated cellulose or nylon.

Two papers concerned with tissue-culture techniques were of particular interest. These were the report, by Fred Giardinello and coworkers (Wistar Institute), of the cultivation of animal cells in a 5-liter fermenter and the report, by E. Z. Rope and associates (Parke, Davis and Company), of the use of tissue culture for the assay of toxins, toxoids, and antitoxins.

The Eli Lilly and Company research

award in bacteriology and immunology was presented to Henry Koffler (Purdue University) at the annual banquet. Koffler's work has dealt with the antibiotics streptomycin and circulin, the structure of the bacterial cell wall, the structure and function of bacterial flagella, and the mechanism of survival of bacteria at high temperatures. Koffler presented the Eli Lilly award address at a general session of the society.

The 1958 meeting of the Society of American Bacteriologists will be held in Chicago.

D. J. MERCHANT

University of Michigan, Ann Arbor

## International Cancer Congress

The seventh International Cancer Congress will be held in London, England, 6-12 July 1958, under the sponsorship of the International Union against Cancer. Scientists and physicians are invited to submit papers on experimental or clinical aspects of cancer or on cancer control. These papers should represent new contributions to knowledge and must not have been published or reported previously.

The deadline for registration without late fee, and also for submission of papers, is 1 Jan. 1958. A preliminary program and application forms for registration, submission of papers, and so forth, are available on request to either of the following: The Secretary General, Seventh International Cancer Congress, 45 Lincoln's Inn Fields, London, W.C. 2, England; or Dr. Harold F. Dorn, Secretary General, Union Internationale Contre Le Cancer, National Institutes of Health, Bethesda 14, Md.

Travel allotments of approximately \$530 each will be available to a limited number of scientists and physicians residing in the United States who may require such assistance. This amount is expected to provide payment of the following: a special 15-day overseas round trip, air tourist fares; a 6-day per diem allowance; and reimbursement for registration fees. Investigators who have been invited to participate in one of the symposia prior to or following the congress may apply for additional funds.

Applications for travel allotments should be submitted in sextuplet in the form of letters giving information on age, training, publications in cancer research or related fields, academic or professional title, and institutional affiliation. These letters should be countersigned by the department director or administrative officer.

Applicants for travel assistance who are submitting papers for presentation at the congress must include six copies of an abstract (not to exceed 250 words) of each such paper. An applicant who

does not plan to present a paper should include six copies of an outline of current investigative work. Such letters, abstracts, and outlines must be submitted to the International Union against Cancer, 2101 Constitution Ave., NW, Washington 25, D.C.

Applications for assistance toward travel expenses are entirely separate from the applications for registration for the congress and for the submission of papers to the Program Committee. All applicants will be responsible for their own passports, visas, registration, travel arrangements, and hotel reservations.

## Forthcoming Events

### November

13-15. Society of Technical Writers, natl. conv., jointly with Assoc. of Technical Writers and Editors, New York. (A. M. Jupiter, P.O. Box 71, Edgewood, Md.)

14-16. American Inst. of Mining, Metallurgical and Petroleum Engineers, semiannual, Chicago, Ill. (H. N. Appleton, AIME, 29 W. 39 St., New York 18.)

14-16. Biology of Normal and Atypical Pigment Cell Growth, 4th conf., Houston, Tex. (M. Gordon, Genetics Lab., American Museum of Natural History, New York 24.)

14-16. Inter-Society Cytology Council, annual scientific, Augusta, Ga. (P. F. Fletcher, 634 N. Grand Ave., St. Louis 3, Mo.)

18-21. Magnetism and Magnetic Materials Conf., Washington, D.C. (L. R. Maxwell, U.S. Naval Ordnance Lab. White Oak, Silver Spring, Md.)

18-21. American Soc. of Agronomy, annual, jointly with Crop Science Soc. of America and Soil Science Soc. of America, Atlanta, Ga. (L. G. Monthey ASA, 2702 Monroe St., Madison, Wis.)

18-22. Citrus Virus Diseases Conf. Riverside, Calif. (J. M. Wallace, Dept. of Plant Pathology, Univ. of California, Riverside.)

18-9. Pacific Science Cong., 9th Bangkok, Thailand. (Pacific Science Board, National Research Council, 2101 Constitution Ave., NW, Washington 25.)

20-22. Structure of the Nucleus, chemical research conf., Houston, Tex. (W. O. Millgiam, Rob't A. Welch Foundation, P.O. Box 1892, Houston 1.)

20-24. National Assoc. for Mental Health, annual, Atlantic City, N.J. (NAMH), 10 Columbus Circle, New York 19.)

22. Tritium in Tracer Applications, symp., New York. (Symp. Committee, New England Nuclear Corp., 575 Albany St., Boston 18, Mass.)

22. Ultraviolet Scanning Microscopy Symp., Philadelphia, Pa. (H. K. Schlegelmilch, RCA Victor TV Div., Bldg. 204-2 Section 219, Cherry Hill, Camden 8, N.J.)

22-23. Tennessee Acad. of Science, 67th annual, Memphis. (W. G. Holladay, Physics Dept., Vanderbilt Univ., Nashville, Tenn.)

25-27. American Acad. for Cerebral Palsy, 11th annual, New Orleans, La. (R.

R. Rembolt, Iowa Hospital-School State University of Iowa, Iowa City.)

25-27. Physics and Dynamics of Fluids, APS, Bethlehem, Pa. (F. N. Frenkiel, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.)

26-28. Central Assoc. of Science and Mathematics Teachers, 57th annual, Chicago, Ill. (L. Panush, Henry Ford High School, Detroit 19, Michigan.)

28-29. American Physical Soc., St. Louis, Mo. (K. K. Darrow, Columbia Univ., New York 27.)

29-30. American Soc. of Animal Production, annual, Chicago, Ill. (H. H. Stonaker, Animal Husbandry Dept., Colorado State Univ., Fort Collins.)

### December

1-6. American Soc. of Mechanical Engineers, annual, New York, N.Y. (C. E. Davies, ASME, 29 W. 39 St., New York 18.)

1-15. Bahamas Medical Conf., 4th, Nassau, Bahamas. (B. L. Frank, 1290 Pine Ave., W. Montreal, Que., Canada.)

2-5. American Rocket Soc., annual, New York. (J. J. Harford, ARS, 500 Fifth Ave., New York 36.)

2-5. Entomological Soc. of America, annual, Memphis, Tenn. (R. H. Nelson, ESA, 1530 P St., NW, Washington 5.)

3-4. Human Factors in Systems Engineering, symp., Philadelphia, Pa. (C. Fowler, American Electronic Labs., 121 N. 7 St., Philadelphia.)

4-8. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

4-10. American Acad. of Optometry, annual, Chicago, Ill. (C. C. Koch, 1506-1508 Foshay Tower, Minneapolis 2, Minn.)

5-7. Texas Acad. of Science, annual, Dallas. (G. C. Parker, Education Dept., Texas A&M College, College Station.)

6-7. Oklahoma Acad. of Science, annual, Enid. (J. T. Self, Dept. of Zoology, Univ. of Oklahoma, Norman.)

7-8. American Acad. of Dental Medicine, New York, N.Y. (S. Ross, 136 E. 36th St., New York 16.)

8-11. American Inst. of Chemical Engineers, annual Chicago, Ill. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

9-11. Fluorides Symp., Cincinnati, Ohio. (Secretary, Inst. of Industrial Health, Kettering Laboratory, Eden and Bethesda Aves., Cincinnati 19.)

9-13. Eastern Joint Computer Conf., Washington, D.C. (H. H. Goode, Dept. of Electrical Engr., Univ. of Michigan, Ann Arbor.)

9-22. Southeast Asia Soil Science Conf., 1st, Manila, Philippines. (I. G. Valencia, Bureau of Soils, P.O. Box 1848, Manila.)

10-11. Water Quality Control for Subsurface Injection, 2nd annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

13-14. Association for Research in Nervous and Mental Disease, 37th annual, New York, N.Y. (R. J. Masselink, 700 W. 168 St., New York 32.)

15-18. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, ASAE, St. Joseph, Mich.)

17-19. Nuclear Sizes and Density Dis-

tributions Conference, Stanford, Calif. (R. Hofstadter, Stanford Univ., Stanford, Calif.)

19-21. American Physical Soc., Stanford, Calif. (W. A. Nierenberg, Univ. of California, Berkeley 4.)

26-27. Northwest Scientific Assoc., annual, Spokane, Wash. (W. B. Merriam, Geography Dept., State College of Washington, Pullman.)

26-30. American Assoc. for the Advancement of Science, annual, Indianapolis, Ind. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 43 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Acad. Conference, annual (Father P. H. Yancey, Spring Hill College, Mobile, Ala.). 28 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (F. B. Dutton, Dept. of Chemistry, Michigan State Univ., East Lansing). 27 Dec.

Alpha Chi Sigma (R. L. Hicks, 1130 E. Jefferson St., Franklin, Ind.).

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 28 Dec.

American Assoc. of Hospital Consultants (J. B. Norman, 8 South Church St., Greenville, S.C.).

American Astronomical Soc. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.). 27-30 Dec.

American Geophysical Union (E. M. Brooks, Dept. of Geophysics, St. Louis Univ., St. Louis 8, Mo.).

American Medical Assoc. Committee on Cosmetics (Mrs. V. L. Conley, AMA, 535 N. Dearborn St., Chicago, Ill.). 28-29 Dec.

American Meteorological Soc. (K. C. Spengler, AMS, 3 Joy St., Boston, Mass.).

American Nature Study Soc., annual (R. L. Weaver, School of Natural Resources, Univ. of Michigan, Ann Arbor). 26-30 Dec.

American Physiological Soc. (F. A. Hitchcock, Dept. of Physiology, Ohio State Univ., Columbus 10).

American Psychiatric Assoc. (M. Greenblatt, Massachusetts Mental Health Center, 74 Fenwood Rd., Boston 15). 29-30 Dec.

American Soc. of Hospital Pharmacists (G. E. Archambault, Pharmacy Branch, U.S. Public Health Service, Washington 25).

American Soc. of Naturalists (B. Wallace, Biological Lab., Cold Spring Harbor, Long Island, N.Y.).

American Statistical Assoc. (V. L. Anderson, Statistical Lab., Purdue Univ., Lafayette, Ind.).

Association of American Geographers (L. L. Ray, U.S. Geological Survey, Washington 25).

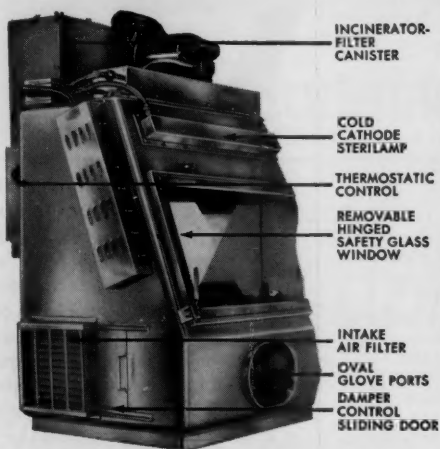
Association for Computing Machinery (J. E. Robertson, Digital Computer Lab., Univ. of Illinois, Urbana).

Astronomical League (W. Garnatz, 2506 South East St., Indianapolis.)

Beta Beta Beta (Mrs. F. G. Brooks, P.O. Box 336, Madison Sq. Station, New York 10). 27 Dec.

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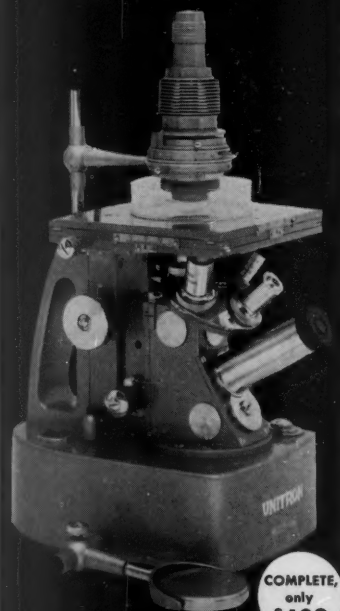
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croft, Dept. of Statistics, Iowa State College, Ames).

Conference on Scientific Editorial Problems, annual (G. L. Scielstad, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.). 26-30 Dec.

Conference on Scientific Manpower, annual (T. J. Mills, National Science Foundation, Washington 25). 30 Dec.

Ecological Soc. of America (A. A. Lindsey, Dept. of Biological Sciences, Purdue Univ., Lafayette, Ind.). 27-29 Dec.

Metric Assoc. (J. T. Johnson, 694 West 11 St., Claremont, Calif.).

National Acad. of Economics and Political Science (D. P. Ray, Hall of Government, George Washington Univ., Washington, D.C.).

National Assoc. of Biology Teachers, annual (Miss I. Hollenbeck, Southern Oregon College of Education, Ashland). 26-31 Dec.

National Assoc. for Research in Science Teaching (G. G. Mallinson, Western Michigan College, Kalamazoo). 26-30 Dec.

National Assoc. of Science Writers (J. Troan, Pittsburgh Press, Pittsburgh, Pa.).

National Council of Teachers of Mathematics (P. Peak, College of Education, Indiana Univ., Bloomington). 27 Dec.

National Geographic Soc. (W. R. Gray, NGS, 16th and M Sts., NW, Washington 6). 29 Dec.

National Science Teachers Assoc. (R. W. Schulz, Emmerich Manual Training High School, 2405 Madison Ave., Indianapolis 25). 26-30 Dec.

National Speleological Soc. (Brother G. Nicholas, LaSalle College, 20th and Olney Aves., Philadelphia 41, Pa.). 28 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio).

Scientific Research Soc. of America, annual (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.). 27 Dec.

Sigma Delta Epsilon, annual (Miss M. Chalmers, Dept. of Chemistry, Purdue Univ., Lafayette, Ind.). 26-30 Dec.

Sigma Pi Sigma (M. W. White, Pennsylvania State Univ., University Park). 27 Dec.

Society for the Advancement of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, 40 E. 40 St., New York 16). 27-28 Dec.

Society for General Systems Research, annual (R. L. Meier, Mental Health Research Inst., Ann Arbor, Mich.).

Society for Industrial Microbiology, Washington Section (W. N. Ezekiel, Bureau of Mines, Washington 25).

Society for Investigative Dermatology (H. Beerman, Univ. of Pennsylvania School of Medicine, Philadelphia 3). 28-29 Dec.

Society of the Sigma Xi, annual (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 27 Dec.

Society of Systematic Zoology, annual (R. E. Blackwelder, Box 500, Victor, N.Y.). 26-31 Dec.

United Chapters of Phi Beta Kappa, annual address (C. Billman, 1811 Q St., NW, Washington, D.C.). 27 Dec.

27. Association for Symbolic Logic, Cambridge, Mass. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

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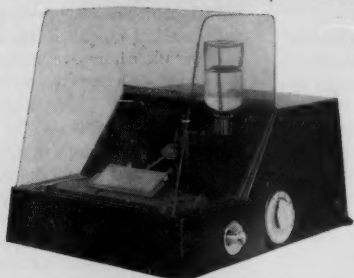
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The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to Science, Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).

■ **SPECTROSCOPE**, for visual spectrochemical analysis, features a solution excitation chamber with an indexing assembly

for easy alignment of electrodes. The electrodes can be replaced after cleaning without readjustment. Thirty-nine elements can be detected. (Fisher Scientific Co., Dept. S665)

■ **MIRROR GALVANOMETER**, manufactured by Hilger and Watts Ltd., has sensitivity up to 2000 mm/μa. The scale image reflected from the galvanometer moves below a stationary index line. A darkened room is not required for reading. Antivibration support is provided within the instrument. (Jarrell-Ash Co., Dept. S654)

■ **CAPACITANCE BRIDGE** covers the range of capacitance from 0 to 120 μf in seven ranges. Accuracy is better than 0.2 percent and within 0.01 μf in the lowest range. Dissipation factors from 0 to 1.05 at a frequency of 1 kcy/sec can be measured in three ranges. Excitation generators and detectors are included in the instrument. (Electro Measurements, Inc., Dept. S649)

■ **AUTOMATIC FRACTION COLLECTOR** consists of an indexing mechanism, a turntable for holding the receiving tubes, and a volumetric siphon. Turntables are available for collection of up to 500 fractions in one run with fraction size ranging from 1 to 100 ml. Drop counting or constant time control are interchangeable. The drop-counting unit may be preset for counts up to 400. The constant timing unit is operative over a range from 18 sec to 120 min. (Research Specialties Co., Dept. S644)

■ **PLASTIC TUBING**, reinforced with metal, will bend around a 5/16-in. diameter spindle without reduction of internal bore. Sizes range from 1/8 to 1 in. internal diameter. Working temperature ranges from 170° to -5°F and working pressure ranges from 100 to 200 lb/in.<sup>2</sup> The tubing is resistant to gasoline, oils, and sea water and is self-extinguishing. (Newage International Inc., Dept. S666)

■ **DIFFERENTIAL TRANSFORMER** features less than 2-mv null voltage. Displacement range is ± 0.02 in. Output is linear within 0.1 percent. Input is 6.3 v at 400 cy/sec. The transformer may be operated at any temperature to 400°F. Micrometer threads on the case permit precise positioning. (Automatic Timing and Controls Co., Inc., Dept. S655)

■ **CYTOANALYZER** is designed to detect abnormal cells by microscopically scanning slides on which specimens from vaginal smears have been placed. The instrument is still in the experimental and testing stage. The scanner examines the pertinent area of the smear and converts optical signals into electrical signals that are fed to a computer. The computer applies certain rules to the signals, measures nuclear size and nuclear optical density of the cells, and distinguishes between normal and suspected cells. Scanning and simultaneous computation take less than 0.2 msec. (National Institutes of Health, National Cancer Institute, Dept. S661)

■ **ULTRAVIOLET STREAK SPECTROGRAPH** provides a two-coordinate photographic record of ultraviolet spectrum versus time. The spectral range is 3050 to 4350 Å. Time resolution is variable, with a lower limit of 0.1 μsec. Linear dispersion on the film is 45 Å/mm, and spec-

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■ **SMOKE-POINT LAMP**, for testing hydrocarbon fuels, is equipped with a calibrated chimney so that the smoke point, the maximum height (in millimeters) of the flame at which the fuel will burn without smoking, can be read off directly. (Central Scientific Co., Dept. S677)

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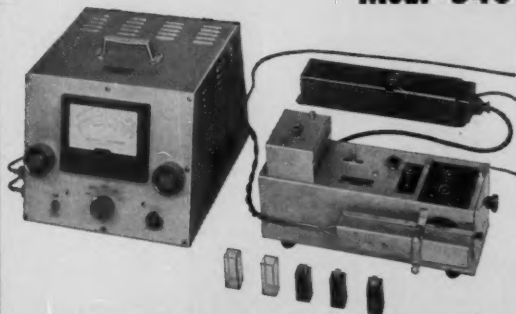
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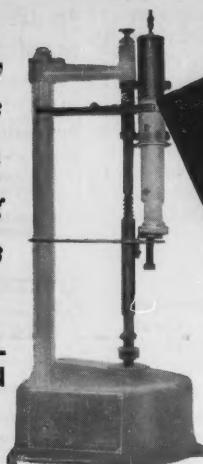
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Indianapolis, December 26-30, 1957

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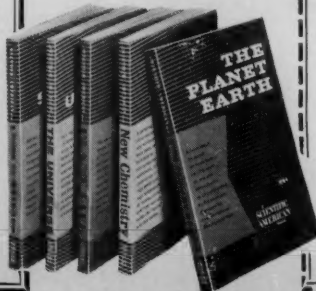
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